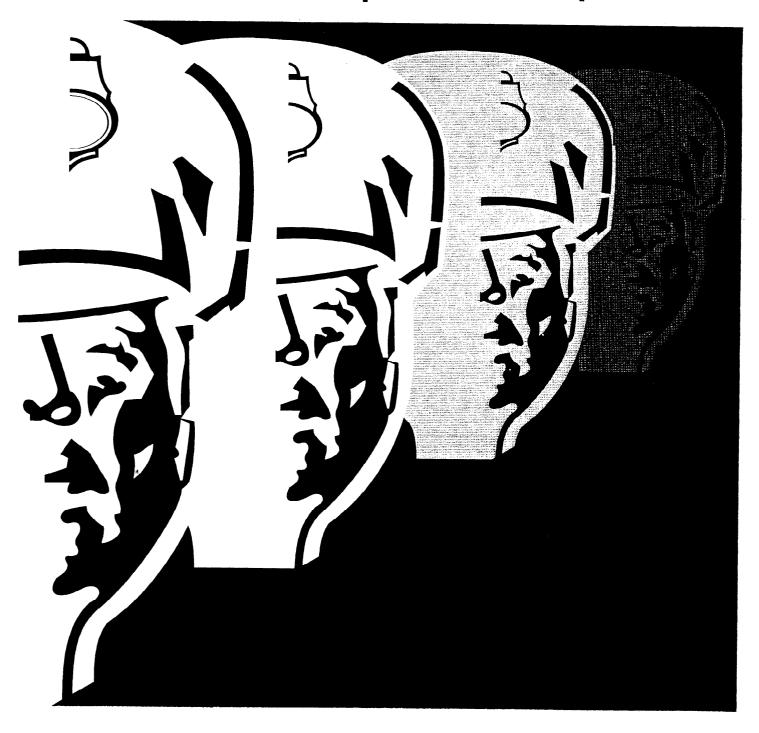# Police Personnel Allocation Manual User's Guide

Municipal Police Departments

POLICE ALLOCATION MANUAL

USER'S GUIDE

Determination of the Number and Allocation of Personnel for

Patrol and Traffic Services for Municipal Law Enforcement Agencies

- Version M3.0 -

Prepared by

THE TRAFFIC INSTITUTE
Northwestern University

for

October 1993

FOREWORD

The <u>Police Allocation Manual</u> (PAM) and <u>Police Allocation Manual</u> <u>User's Guide</u> were developed and field tested by The Traffic Institute of Northwestern University under a contract **(No DTNH22-92-C-05051)** issued by the National Highway Traffic Safety Administration, U.S. Department of Transportation. Principal Investigator and author for the study was Dr. William **Stenzel.** Dr. **Stenzel** was assisted by Mr. Roy **Lucke** who directed the design, implementation, and coordination of the field test activities of the project. The Contracting Officer's Technical Representative for the project was Mr. David **Seiler** (Office of Enforcement and Emergency Services).

The <u>PAM</u> project was initiated in June **1988.** Phases I and II were **used to** produce a staffing and allocation procedure and manual for statewide law enforcement agencies. Phase III was used to modify the products for sheriffs' departments. In Phase IV, the <u>Manual</u> and <u>Guide</u> were revised and field tested for use by municipal law enforcement agencies. The Phase I field test was conducted during the summer and fall of **1989,** and the Phase I products were completed in February **1990.** Phase II of the project was completed in January **1991** and the final version for state-level agencies (Version **4.0)** was completed in July **1991.** The final version for Phase III (Version **S3.0)** was completed for sheriff's departments in September of **1991.** Activities to extend the PAM methodology to municipal agencies (Phase IV) were initiated in October **1992.**

The project team wishes to identify and thank the municipal police departments that served as field test sites during Phase IV of the study. (The project liaison person for each agency is identified below with an **"*."** The ranks and titles reflect those held during the field test.)

Addison (Illinois) Police Department	Chief Melvin **Mack** *Deputy Chief Timothy Hayden
Boca Raton (Florida) Police Department	Chief Peter A. **Petracco** *Deputy Chief Philip **Sweeting**
Boise (Idaho) Police Department	Chief James **J. Carvino** *Officer Rich **Sohnebly**

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SECTION **1:** <u>Introduction</u>

<u>Police Allocation Manual **Project**</u>

The <u>Police Allocation Manual User's Guide</u> (herein after referred to as the <u>Guide</u>) is intended as a companion document to the <u>Police Allocation Manual</u>, Version **M3.0,** which can be used to determine the number and allocation of personnel for patrol and traffic services for municipal police departments.

Both the <u>Guide</u> and the <u>Police Allocation Manual</u> (herein after referred to as the <u>Manual</u>) were developed by The Traffic Institute of Northwestern University under contract to the National Highway Traffic Safety Administration **(NHTSA),** U.S. Department of Transportation. Additional information about the project is available in the reports submitted to **NHTSA** in February **1990,** March **1991,** September **1991,** and October **1993** respectively.

<u>Police Allocation Manual Procedures</u>

The procedures for determining the number of personnel are based on an analysis of officer workload in terms of the amount of time required to complete various tasks. All on-duty patrol activities are assigned to four categories:

- <u>Reactive</u>: answering calls-for-service and responding to accidents;

- <u>Proactive – Self-Initiated and Community-oriented **Policing**</u>: traffic enforcement, field interrogations, motorist assists, community-oriented policing (COP);

- <u>Proactive – Uncommitted Patrol</u>: patrol on uncommitted time; and

- <u>Administrative</u>: office time, vehicle maintenance, meal time, etc.

The '*Proactive-Uncommitted **Patrol"** category refers to uncommitted time only (i.e., time not spent on reactive, self-initiated/COP, or administrative activities). Self-initiated activities that occur as a result of "uncommitted **patrol"** time are included in the

"self-initiated" category. Time spent **looking** for violators is defined as "uncommitted patrol **time"** while time spent <u>with</u> violators is defined as "self-initiated time."

The procedures rely on historical data and user-supplied performance objectives. These data and objectives are used in nine worksheets in the <u>Manual</u> to guide the user through the process of determining how many officers are needed for each of the categories identified above. For two of the categories, Reactive (Worksheet **3)** and Proactive-Uncommitted Patrol (Worksheet **5),** workload and performance objectives are used to derive the number of on-duty officers required daily for each category. For the Administrative (Worksheet **2)** and Proactive-Self-Initiated/COP (Worksheet **4)** categories, historical data and performance objectives are used to determine the proportion of officer on-duty time that should be spent on these activities.

The results of worksheets 2 through 5 are combined at the beginning of Worksheet 6 to determine the average number of on-duty officers needed each day. This result is modified in worksheets **6, 7,** and 8 to account for two-officer units, minimum staffing, special assignments, field supervisors, benefit time off, and the number of command staff.

Worksheets 1 **-** 8 are used to obtain patrol staffing requirements for an **"autonomous** patrol **area" (APA).** The staffing requirement for an entire jurisdiction is obtained by adding the staffing requirements for all **APAs** in the jurisdiction. (In many cases, a jurisdiction will consist of a single **APA.)** Worksheet 9 is used to allocate or distribute a total number of officers among several patrol areas **(APAs)** or among distinct time periods (e.g., shifts)'. A complete description of the methodology is presented in Chapter 2 of the <u>Manual</u>.

<u>Contents of the User's Guide</u>

The <u>Guide</u> consists of four sections and four appendixes. Section 1 **("Introduction")** provides an overview of the project and methodology, and the contents of the <u>Guide</u>. Sections 2 and 3 provide specific information and guidelines regarding "General Implementation Strategies" and **"Data** Definition and Collection **Issues"** respectively. The material in sections 2 and 3 is summarized in a **"Recommended** Data Collection and Implementation **Procedure"** in Section **4.** Appendix A contains a list of the data required for each of the nine worksheets in the <u>Manual</u>. Appendix B is a glossary of terms and notation used in <u>Manual</u>. Appendix C contains an example of the nine worksheets in the <u>Manual</u> in

completed form.   Appendix D contains derivations of the major
formulas used in the <u>Manual</u>.

How to Use the Guide

The <u>Guide</u> has been written for use as a reference document to
assist <u>Manual</u> users.   It is anticipated that no one will study this
document section by section, front to back. Rather, it is expected
that the <u>Guide</u> will be used as questions about data definitions,
data collection,   and the use **of** particular worksheets arise.
First-time users will be interested in the implementation strate-
gies discussed in Section 2 and the recommended procedure outlined
in Section **4.** Experienced users will refer to the information on
data definitions and collection in Section **3.**

SECTION **2:** <u>General Implementation</u> **Strategies**

This section provides observations about the implementation and
uses of the <u>Manual</u> for determining staffing requirements.   The
observations are based on experience gained from field tests of the
PAM procedures during all phases of the project.   The first part
below examines what the <u>Manual</u> can and cannot do. This is followed
by suggestions for first-time users.

Uses and Limitations of the Manual

The procedures in the <u>Manual</u> represent a **model** of police
staffing.   The steps in the worksheets are based on mathematical
and logical relationships between workload, patrol performance, the
characteristics of the patrol area, and the total number of
officers required. Analysts divide models into two broad catego-
ries: descriptive and prescriptive.   Identifying which category
the PAM model belongs to is useful in recognizing how the model can
be used and its limitations.

The PAM model is a prescriptive model; that is, using information
about the workload, the desired performance levels, and the
characteristics of the jurisdiction, the model can be used to
prescribe how many officers are needed.   The model is <u>not</u> a
descriptive (or predictive) model; that is, it is not possible to
specify a fixed number of officers, the workload, and other **char-**

acteristics of a jurisdiction and use the model to describe (or predict) what level of patrol performance can be expected. Similarly, it is not possible to use the PAM model to predict what the change in patrol performance or workload will be if the number of officers is increased.

The prescriptive nature of the PAM model provides police planners with a powerful tool. Not only can **the** Manual be used to determine appropriate staffing levels, it can also be used to answer **"What if?"** questions. For example, what will be the impact on staffing if the workload increases by **20%** or if the average travel time to emergency activities is reduced by 1 minute?

Model ****failures**** can occur because of the limitations of the procedure itself and from incorrect or unrealistic expectations by police planners. The PAM model cannot provide the answers to all staffing and allocation questions. For example, the model is not capable of predicting changes in performance as staffing levels change. Additional limitations are:

- The PAM model cannot correct or compensate for inaccurate or incomplete data. This limitation is merely an application of the **"law"** most often associated with data processing; that is, **Garbage in, garbage **out."** The model is more sensitive to the accuracy of some data items than others. This fact is important in determining what level of effort should be expended in data collection. (See the discussion below in Section **4:** **Recommended Data Collection and Implementation Procedure.**).

- The PAM model can only prescribe how many officers are needed when performance objectives are provided; that is, when someone or some group decides what level of service is desired. The Manual is not a method for determining staffing levels that can be completed without management involvement or input.

- The PAM model cannot be used to predict the future workload of a patrol area.

- The PAM model, by itself, will not convince council members or policy makers to increase funding support for additional staff. Decisions on staffing levels eventually reflect fiscal and political realities. The model will strengthen requests for additional staff, but cannot guarantee their acceptance.

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Guidelines for First-Time PAM Users

For persons who are using PAM for the first time, it is recommended that the steps outlined in Chapter 1 in the Manual and the recommended procedure discussed in Section 4 below be followed. The steps described in Chapter 1 are listed below:

- Read Chapter 2 in the Manual to gain an overview of the PAM model. (Some users may also want to review the material in Appendix D in the Guide.)

- Review Appendix A in the Guide.

- Review chapters 3 and 4 in the Manual with reference, as needed, to appendixes B and C in the Guide.

- Estimate the data collection effort.

- Assess the benefits of using the PAM model. (Only use PAM if the benefits to the agency outweigh the cost of the data collection effort.)

- Review the recommended procedure in Section 4 in the Guide.

- Collect the required data.

- Complete the worksheets.

- Review the results and adjust the input data.

Two important guidelines to remember, particularly for first-time users, are:

1. It is not necessary to complete all sections of each **worksheet** or even all the **worksheets** to obtain useful results.

2. It is not necessary to have highly accurate values for **every** input data item to obtain useful results. (See Section 4 below.)

The remainder of this section provides an overview of the model.

Worksheets 1 - 8 in Chapter 3 in the Manual are used to determine the patrol staffing level of an **APA;** that is, the **"number"** of officers

required.   Worksheet 9 in Chapter 4 in the <u>Manual</u> is used to determine how the total number of officers for several **APAs** should be **"distributed"** or **allocated** over the **APAs.**   (Remember that an **APA** can be a geographical area or a unit of time such as a shift or day of the week.) Worksheets 1 – 8 can be completed without completing Worksheet **9;** and it is not necessary that the staff totals used in Worksheet 9 be calculated based on worksheets 1 – 8 if an alternative method for estimating staffing levels is available.

Within worksheets 1 – **8,** it is possible to identify entire worksheets and sections of worksheets that may not need to be completed. For example, if the PAM procedures are used to determine the average number of **on-duty** officers required each day, then only worksheets 1 – 5 and Section **6.1** are needed.

Within some worksheets, it may not be necessary to complete all sections. For example, in Worksheet **2,** the user may use either Section **2.1** or Section **2.2.** In Worksheet **3,** Section **3.1** can be used if an agency-prefers to separate accidents from Other **CFS.** If this is not necessary, Section **3.1** can be skipped, and accidents can be combined with Other **CFS** in Section **3.2.** In Worksheet **4,** the user may use either Section **4.1,** Section **4.2,** <u>or</u> Section **4.3.** If an agency does not explicitly identify time **spent** on community-oriented policing, Section **4.5** can be skipped. In Worksheet **5,** the user may use either Section **5.2** <u>or</u> sections **5.3** and **5.4.** In Section **5.1,** the user has the option **of using** as many or as few roadway types as is appropriate for the **APA.**

Beginning with Section **6.2** in the <u>Manual</u>, the remaining sections and worksheets, which the user may elect not to use, provide adjustments to the average number of on-duty officers required per day derived in Section **6.1.** Sections **6.2** and **6.3** are used to account for agencies that use two officers per unit for some patrols and for **APAs** with minimum staffing requirements. Worksheet 7 is used to account for officers on special assignments and to determine the number of on-duty field supervisors required. Worksheet 8 is used to determine the total number of officers and field supervisors (i.e., both on-duty and off-duty) and the total number of command staff required.

SECTION **3:** Data Definition and Collection Issues

Data Collection Categories

The PAM model requires that all officer activities for patrol be classified into four categories. The first step in using the model is a **"tailoring"** process in which each type of officer activity is assigned to a particular category. Municipal law enforcement agencies define and use similar kinds of activities in each category. Due to differences in operational practices, data definitions, and data collection procedures, however, it is likely that no two agencies will define the data items to be included in each category in precisely the same way.

The lists below indicate the kinds of activities that were included in each of the four categories by agencies that participated in the PAM field tests.

Administrative Time

- on-duty court time
- training (less than one day)*
- meals
- auto maintenance
- equipment maintenance
- agency administrative duties
- relay of equipment
- roll call
- briefings
- report writing (if not put into reactive time)

* Time off for training that requires one or more days can be included in the calculations for the shift relief factor in Worksheet **8.**

Reactive Time (dispatches to accidents, criminal activities, emergencies, and non-emergencies)

- travel time
- on-scene time
- report writing time
- follow-up investigation
- reactive time by all units dispatched

- assists to other agencies
- escort and relay
- motorist assistance (if dispatched)
- traffic control (if dispatched)
- searches for missing and wanted persons

Proactive Time - Self-Initiated/COP Activities

- traffic stops (traffic citations and warnings)
- motorist roadway assistance
- criminal investigation
- traffic control
- field interrogations
- community-oriented policing activities

Proactive Time - Uncommitted Patrol

- patrolling assigned areas (includes both moving and
  stationary patrol)

The ability to tailor the procedures to reflect the data collection practices of an agency is a strength of the model. Rather than requiring an agency to redefine existing data collection procedures to **"fit"** the model it is possible to tailor the model to fit the agency. The flexibility that such tailoring requires that caution be used when comparing the staffing estimates for different agencies. Unless two agencies use the same data items, defined in the same way, for each activity category, it may not be possible to reliably determine the underlying causes for differences in staffing estimates.

Decisions about which category each activity is assigned to have relatively little impact on the final staffing estimate. More important than the question of which category to use for each workload item is the need to insure that all officer patrol work-load activities are included in the model.

Selecting Autonomous Patrol Areas **(APAs)**

The model estimates the total patrol staffing for an agency by first determining the staffing levels for patrol areas using the following steps:

- The entire jurisdiction is divided into a number of autonomous patrol areas. The **APAs** must cover the entire jurisdiction and not overlap.

- The model is used to determine the staffing level for each **APA.**

- The individual **APA** results are added together to obtain the staffing requirement for the entire jurisdiction.

The selection of the **APAs** is dictated by the requirement that each **APA** exhibit the following characteristics:

- Virtually all **CFS** that originate in the **APA** are handled by officers assigned to the **APA** or, **conversely,** almost none of the **CFS** that originate in the **APA** **are** handled by officers assigned to areas outside of the **APA;**

- Officers assigned to the **APA** are rarely dispatched to **CFS** outside of the **APA;** and

- Although officers may be assigned to specific patrol areas within the **APA,** officers are routinely dispatched, as needed, to **CFS** anywhere within the **APA.**

The first two characteristics define what is meant by **"autonomous."** Simply stated, it means that the **APA** must be, for the most part, a self-contained or independent operational area with little or no cross-over of personnel either into or out of the area. (As a guideline, **90%** of the **CFS** in the **APA** should be handled by units assigned to the **APA.)**

The third characteristic indicates that the **APA** cannot itself be a collection of smaller **APAs;** that is, all the units assigned to the **APA** must be routinely dispatched to **CFS** throughout the **APA.** If units are only dispatched to **CFS** within their patrol areas and are rarely dispatched to **CFS** in other parts of the **APA,** then consideration should be given to dividing the area into several **APAs.**

The size of each **APA** within a jurisdiction will vary depending on workload, population density, and traffic volume. From an operational perspective, **APAs** can be viewed as separate command areas, often characterized by the use of separate radio frequencies

for dispatch. For some agencies, **APAs** may be defined by natural or manmade barriers; for example, an area that is isolated from the rest of the jurisdiction by a river or an expressway.

For most municipal agencies, only one geographic **APA** is appropriate for the entire jurisdiction. Few municipal police agencies will use more than 3 or 4 **APAs** for their jurisdictions. If Worksheet 9 is used to allocate officers over shifts or days of the week, then each shift or day of the week is defined as a separate **"APA."**

Worksheet Options and the Use of Performance Standards

To provide as much flexibility as possible, four of the worksheets in the Manual give the user two or three different ways to derive a particular value. The decision about which option to use in each case is based on data availability and the desire of the agency to set an operational performance standard as a matter of policy.

Occasionally, first-time PAM users are disappointed to learn that all the calculations are not based on historical data and/or **"national"** standards for staffing or workload. (No such national standards exist.) Although, it is theoretically possible to use the model based entirely on historical data, this is rarely done for two reasons. First, it is difficult to collect all the required data, and second, use of historical data in all the worksheets should yield staffing totals, assuming the **model** is valid and accurate, that will replicate current staffing levels. While this may be useful in verifying the validity of the model, it is more likely that agencies will be interested in examining the impact on staffing levels if one or more of the current workload, performance, or other data items are altered.

The remainder of this section briefly outlines the options ex-plicitly available to the user in the worksheets. It should be noted that the term "explicitly" is used to highlight the fact that the user **"implicitly"** has options for almost every data item required (i.e., the value used for most data items can be set by policy or based on historical data). For each of **the** options identified below, the decisions of the Phase IV municipal field test agencies about which option was used and the average value selected or derived are shown in Table **1.** (The data presented in Table 1 is based on ten applications of the PAM procedures; that is, the PAM procedures were used for ten different **APAs.)**

Administrative Time Per Officer (Worksheet **2).** Worksheet 2 has two options for estimating the average number of minutes per

Table 1

VALUES USED FOR SELECTED PAM INPUT DATA ITEMS

- 1993 Phase IV Field Test, Ten Agencies (10 Worksheet Applications) -

Worksheet Section	Data Item (Worksheet Location)	Number of Applications	Units of Measurement	Average	Minimum	Maximum
2.1	Administrative Time Policy (2.1)	3	Min/Hr/Officer	9.33	6.00	12.00
2.2	Administrative Time Historical (2.2.4)	7	Min/Hr/Officer	12.57	6.79	19.50
3.1	Average Service Time Accidents (3.1.2)	10	Hours/Accident	1.57	0.83	2.50
3.2	Average Service Time Other CFS (3.2.2)	10	Hours/CFS	0.81	0.50	1.50
4.1	Self-Initiated Time Policy - Direct (4.1)	3	Min/Hr/Officer	11.67	5.00	20.00
4.2	Self-Initiated Time Policy - Indirect (4.2.7)	0	Min/Hr/Officer	----	----	----
4.3	Self-Initiated Time Historical (4.3.4)	7	Min/Hr/Officer	8.57	5.04	11.96
4.5	Community-Oriented Time (4.5.3)	3	Min/Hr/Officer	3.00	0.00	6.00

Table 1 (continued)

VALUES USED FOR SELECTED PAM INPUT DATA ITEMS

- 1993 Phase IV Field Test, Ten Agencies (10 Worksheet Applications) -

Worksheet Section	Data Item (Worksheet Location)	Number of Applications	Units of Measurement	Average	Minimum	Maximum
4.6	Total Self-Initiated Time (4.6)	10	Min/Hr/Officer	10.40	6.71	20.00
5.1	Primary Roadways Patrol Speed (5.1.2.3)	10	Miles/Hour	23.85	10.00	30.00
5.1	Primary Roadways Patrol Interval (5.1.2.4)	10	Hours	2.33	0.25	4.00
5.1	Secondary Roadways Patrol Speed (5.1.3.3)	10	Miles/Hour	18.17	8.00	25.00
5.1	Secondary Roadways Patrol Interval (5.1.3.4)	10	Hours	6.14	0.25	24.00
5.1	Residential Roadways Patrol Speed (5.1.4.3)	10	Miles/Hour	14.55	6.00	20.00
5.1	Residential Roadways Patrol Interval (5.1.4.4)	10	Hours	49.60	4.00	168.00

Table 1 (continued)

VALUES USED FOR SELECTED PAM INPUT DATA ITEMS

- 1993 Phase IV Field Test, **Ten Agencies** (10 Worksheet Applications) -

Worksheet Section	Data Item (Worksheet Location)	Number of Applications	Units of Measurement	Average	Minimum	Maximum
5.2	Non-Preemptable Other CFS (5.2.2.3)	9	Percent of CFS	19.56	6.00	38.00
5.2	Non-Preemptable Admin. Activities (5.2.2.6)	9	Percent of Admin. Act.	11.44	0.00	40.00
5.2	Non-Preemptable Self-Initiated Act. (5.2.2.7)	9	Percent of S.I. Activities	21.22	1.00	75.00
5.2	Patrol Availability Immediate Resp. (5.2.4.1)	9	Percent of CFS	79.89	70.00	99.00
5.3	Area Patrol - Response Speed for Emergency Activities (5.3.2.2)	8	Miles/Hour	38.13	25.00	60.00
5.3	Area Patrol - Response Time Goal for Emergency Activities (5.3.2.3)	8	Minutes	4.50	3.00	7.00
6.2	Two-Deputy Patrols (6.2.1)	10	Percent of Patrol Units .	0.42	0.00	4.20
7.1	Field Supervision Span of Control (7.1.1)	10	No. of Officers per Supervisor	6.34	3.00	9.00

Table 1 (continued)

VALUES USED FOR SELECTED PAM INPUT DATA ITEMS

— **1993** Phase IV Field **Test,** Ten Agencies (**10** Worksheet Applications) —

Worksheet Section	Data Item (Worksheet Location)	Number of Applications	Units of Measurement	Average	Minimum	Maximum
7.1	Field Supervisor Time on Patrol (7.1.2)	10	Percent of Time on Patrol	24.00	0.00	80.00
8.2	Officr On-Duty Time (8.2.7)	10	On-Duty Hrs per Year per Officer	1,671.80	1,346.00	1,866.00
8.5	Total Staff (8.5.4)	10	Total No. of Officers, Field Supervisors, and Staff and Command Personnel	116.50	23.00	473.00
	Current Staff	10	Total No. of Officers, Field Supervisors, and Staff and Command Personnel	93.90	16.00	420.00

hour per officer to be spent on administrative activities. Section **2.1** allows the user to set the average number of minutes. Section **2.2** directs the user through the process of deriving the value based on historical data. Table 1 indicates that among the **10** field test applications during Phase IV, three were based on Section **2.1** (Policy) and seven were based on Section **2.2** (Historical Data). The average time based on historical data, **12.57** minutes per hour per officer, was higher than the average of **9.33** minutes per hour per officer based on policy.

　　　　Self-Initiated/COP Time Per Officer (Worksheet **4)**. Worksheet 4 has three options for determining the average number of minutes per hour per officer to be spent on self-initiated/COP activities. Section **4.1** allows the user to set the average number of minutes. Section **4.3** directs the user through the process of deriving the average value based on historical data. (Sections **4.1** and **4.3** parallel the options provided in sections **2.1** and **2.2** in Worksheet **2.)** The third option, in Section **4.2,** is a combination of the **options** available in **4.1** and **4.3.** The derived value is based both on a policy decision (i.e., the average number of self-initiated contacts per shift per officer) and the average time spent on each contact based on historical data. Agencies that are using community-oriented patrol strategies have the option of identifying how much time each officer should spend on such activities in Section **4.4.** During the field test, seven out of the ten applications determined self-initiated time based on historical experience (Section **4.3).** The average value for the 7 applications was **8.57** minutes per hour per officer. None of the field test agencies used the policy-indirect option in Section **4.2.** Some field test agencies were hesitant to use the policy option in Section **4.2** since it could be interpreted as a system of enforcement **"quotas."** Three agencies set self-initiated time per officer by policy (Section **4.1).** The average time selected by policy was **11.67** minutes per hour per officer.

　　　　Uncommitted Patrol Availability (Worksheet **5)**. Worksheet 5 **gives the** user two options for determining the number of on-duty officers needed per day for uncommitted patrol **"availability"** (Section **5.2** and sections **5.3** and **5.4).** This value is then compared with the average number of officers needed for uncommitted patrol **"visibility"** (Section **5.1)** to derive a total number of on-duty officers needed per day for proactive-uncommitted patrol. Section **5.2** is used to determine the number of officers needed to have enough units available to respond immediately to emergency accidents and **CFS.** Section **5.3** is used to determine the number of officers that are needed to provide an average travel time to emergency activities. Section **5.4** is used to determine the number of officers that are needed to provide an average travel time to

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non-emergency reactive activities.   The average travel time
objectives, are set by the user.   Table 1 identifies the average
patrol speed and patrol interval specified by the field test
agencies in Section **5.1** for three roadway types (primary, second-
ary, and residential).   For the nine agencies that used Section
5.2, the average immediate response objective was **79.89** percent.
For travel time calculations in Section **5.3,** the average target
response time for emergency activities was **4.50** minutes.

Strategies for Controlling the Data Collection Effort

Use of the model can vary in difficulty depending on the availabil-
ity of data and the amount of work required to obtain the data.
When all **APAs** for a jurisdiction or for even parts of a jurisdic-
tion are considered, the magnitude of the data collection effort
required may be significant.   **For** agencies that elect to use
several **APAs,** the field test experience revealed two strategies for
limiting this effort.

   APA-Independent Data.   There are a number of data items that
are independent of the location or other attributes of each **APA.**
As a result, it may be possible to use the same value for a
particular data item for all **APAs.**   Although the specific data
items will vary from one agency to another, the following list
should apply to most:

- average number of on-duty hours per year per officer,

- average number of officers per field supervisor,

- average fraction of time spent on patrol by field
  supervisors,

- average service time for accidents,

- average service time for other **CFS,**

- percent of units with two officers,

- average time per hour spent on administrative activ-
  ities per officer,

- average time per hour spent on self-initiated/COP
  activities per officer, and

- shift length.

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APA-Dependent Data. There are also a number of input data items that will likely vary by **APA** within the same jurisdiction. A partial list would include:

- number of roadway miles by roadway type,

- number of accidents and other **CFS,**

- average patrol speed by roadway type,

- patrol interval by roadway type,

- immediate response percentage,

- average response speed,

- average travel time objectives for emergency and **non-emergency** activities,

- amount of patrol available from officers on special assignment, and

- presence and influence of minimum staffing limits.

During the Phase I field test for state-level agencies, several sites were able to control the data collection effort for **APA-dependent** data by recognizing that those data items that vary by **APA** are often correlated with the proximity of the **APA** to urban or rural areas. Groups of **APAs** were categorized by their **"urbanicity"** and identical input data values were used for all **APAs** in the same category. Municipal agencies may be able to group **APAs** based on their residential or commercial nature.

Discussion of Individual Data Items

The PAM model estimates the staffing level for an **APA** by accounting for the time that officers need to perform patrol activities. The model uses four time categories and general definitions about what activities are included in each category. The current model represents only one way of categorizing and defining patrol activities, The significance of this observation is that regardless of what categories and definitions are used, they must account for all time spent on patrol activities. This section provides an **overview** of some of the data-related issues that arose during the field test.

Command personnel. Section **8.4** in the Manual is used to include the number of command personnel for the **APA.** The value is supplied by the user. It is not necessary, however, to use this section to obtain estimates for the number of officers and field supervisors that are required; these values are obtained in Section **8.3.**

Emergency and non-emergency activities. Emergency activities are accidents and other **CFS** for which police officers must respond immediately. Typically, emergency activities are defined as incidents in which lives and/or property are at risk and rapid police response can limit that risk. Crime-in-progress calls and serious traffic accidents are usually classified as emergency activities. Non-emergency activities are accidents and other **CFS** that require a police presence without the need for a rapid response.

Immediate response percentage. The immediate response percentage is used in Section **5.2** to determine how many on-duty officers are needed each day to insure that an officer will be available for immediate assignment for emergency incidents. It is important to note that **"immediate"** response is not the same as **"rapid"** response. Immediate response merely implies that at least one officer will be available, somewhere in the **APA,** for the assignment. No consideration is given to how far away the officer may be from the incident. Users that are interested in the number of officers that are needed to maintain a user-specified average travel time in responding to emergency incidents should use Section **5.3.**

Non-preemptable and **preemptable** activities. The percentage of non-preemptable activities is used in the model to determine the size of the officer **"pool"** that is necessary to insure that the immediate response and travel time performance objectives are met. When an officer is engaged in a preemptable activity, he/she is counted as part of the force that is available for immediate dispatch to emergency calls. Officers assigned to non-preemptable calls are not available for assignment (emergency or non-emergency) until he/she completes the call or is relieved by another officer. An **activity** may be non-preemptable because the assigned officer is not available for reassignment **(e.g.,** time spent in court and on the range) or because there is a significant need for the officer to remain at the scene (e.g., to control traffic near an accident or to collect short-lived evidence at a crime scene).

On-duty hours on patrol per **year** per officer. The average number of on-duty hours per year per officer is used in Section **8.2** to calculate the **shift relief **factor" (SRF).** The shift relief factor indicates how many officers are needed to cover one shift position every day. For **8-hour** shifts, **SRFs** typically range from

1.60 to **1.90;** i.e., for each shift position, a total of **1.6** to **1.9** officers is needed.   A common question is whether the average number of on-duty hours per year per officer is **2,080** hours which is obtained by multiplying **52** weeks by **40** hours per week.   The **2,080** hours equals the number of hours for which an officer is **"paid"** for one year and is always greater than the number of actual on-duty hours because it includes paid **"time off" (e.g.,** vacations and holidays).   The average number of on-duty hours on patrol per year per officer is the number of hours each officer is on duty and on patrol.

Although it is easy to see why "benefit time **off"** such as vacations and holidays should not be included, there are other situations in which the definition of **"on-duty"** time is more difficult to interpret.   The difficulty arises because not all on-duty time is spent on patrol.   As an example, consider an officer who is sent to a two-week training program.   An administrator may argue that the officer is **"on-duty"** whether he/she is on patrol or at a training program.   A patrol commander, on the other hand, may argue that when the officer is gone for two weeks, there is a staffing shortage on patrol that is just as real as if the officer were on a two-week vacation.   From the commander's point of view, the officer is not **"on-duty"** in the sense that he/she is not on patrol, and as a result, the two weeks spent at training should not be included as on-duty time.   There is no one **"right"** way to define on-duty patrol time; it depends on the policies and practices adopted by each agency.   Since the definition used to calculate **SRFs** may vary from one agency to another, the following guidelines should be noted:

- The calculation of the shift relief factor in Section **8.2** requires that a definition of **"on-duty** patrol** time, appropriate for the agency, be adopted; and

- The comparison of shift relief factors for different agencies is not appropriate unless the same definition of **"on-duty** patrol" time is used by both agencies.

Table 1 indicates that the average on-duty time per year per officer was **1,671.80** hours that, assuming **8-hour** shifts, produces a **SRF** of **1.747** officers per shift position.

   Patrol interval.   Patrol interval is used in Section **5.1** of the Manual as a measure of the level or intensity of patrol coverage. It is measured in hours and indicates the average time that a stranded motorist would have to wait to see an officer come by or the frequency with which a resident would see an officer pass his/her house on free patrol (i.e., proactive-uncommitted patrol).

As an example, a patrol interval of one hour means that a motorist, stranded on the roadway, would have to wait an average of one hour before seeing an officer. While there is no theoretical upper limit to the patrol interval, the largest value used during the field test was **168** hours (i.e., a resident would see a patrol officer about once a week). Table 1 indicates that the average patrol interval for primary roadways for the field test was only **2.33** hours. For secondary roadways, the average was **6.14** hours, and for residential roadways, the average was **49.60** hours.

   Patrol speed. Patrol speed is used in Section **5.1** as part of the calculation to determine the number of on-duty officers required to meet a specified patrol interval. Average patrol speed and average response speed (discussed below) are often among the most difficult data items to obtain. A number of different approaches can be used to estimate this value:

- Use of log sheets. Average patrol speed equals the total number of miles driven while on **"patrol"** divided by the total time spent on **"patrol."** The mileage and time estimates must be based on @@proactive-uncommitted **patrol"** as defined in the PAM model; that is, only mileage and time spent on uncommitted patrol (including stationary patrol) should be used. Any mileage accumulated for or time spent on activities that fall into any of the non-uncommitted patrol categories (i.e., administrative, reactive, **and self-initiated/C-OP)** is not included.

- Ride-along observers. Some agencies have attempted to estimate average patrol speeds by having observers ride along with officers while on patrol. The presence of an observer, however, may cause changes in driving behavior.

- **Survey** of officers. Another approach is to survey officers to obtain an estimate of the average speed. This method, however, may not be useful since human recollection is often not reliable for estimating @@average@@ speeds. (There is a tendency to remember only the cruising or top speed and to forget times when a unit is either stationary or moving very slowly.)

In the last section of the Guide, a general approach **to using** the PAM model is outlined. One of the suggestions is that users must exercise judgment in determining how accurate each input value

should be and how much effort should be expended in obtaining each
item. Patrol speed is a data item that can, if one is not careful,
require far more effort than may be justified. In Table **1,** the
average patrol speeds used by the field test agencies were **23.85**
MPH for primary roadways, **18.17** MPH for secondary roadways, and
14.55 MPH for residential roadways.

Response speeds. Response speeds are used in sections **5.3** and
5.4 to estimate the number of on-duty officers required to maintain
user-specified average travel times for emergency and non-emergency
responses. Like patrol speed, this data item may be difficult to
obtain. The same procedures outlined above for determining patrol
speeds can also be used to estimate response speeds. If log sheets
are used, mileage and times must be based on travel to emergency
and non-emergency incidents only. The influence of ride-along
observers and the unreliability of human recollection to estimate
response speeds may be even more pronounced. PAM users are
encouraged to follow the recommended data collection strategy
outlined in the last section of the Guide to avoid unnecessary
effort spent on obtaining response speed estimates. In Table **1,**
the average speed (over all roadway types) for responses to
emergency activities is **38.13** MPH.

Roadway types. To use the procedures in Section **5.1,** the user
must define one or more roadway types for the **APA.** As an example,
all roadways in the **APA** could be divided into expressways,
arterial, and residential streets. (In the example presented in
Appendix **C,** the roadways are divided into arterial, collector, and
residential.) The user must also indicate how many miles of each
roadway type there are in the **APA.** These categories are used in
Section **5.1** for the derivation of the number of on-duty officers
needed each day to meet the patrol interval objectives set by the
user for each roadway type. PAM users are not required to use any
particular set of roadway categories or to use a specific number of
roadway types. The critical issue is not whether three roadway
types are used, but rather that all roadway types and miles
routinely patrolled in the **APA** are included in the procedures for
deriving agency staffing estimates. The selection of how many
roadway types and how each should be defined will vary from agency
to agency. It **is** recommended that the definitions rely on the
following factors:

- traffic volume,

- use of **the** road (i.e., feeder, collector, thruway,
  etc.),

- average speed,

- need for police patrol, and

- the availability of traffic and operational data by
roadway type.

   Self-initiated/COP time. Worksheet 4 is used to determine the
average number of minutes per hour per officer for self-initiated
and community-oriented policing activities. Self-initiated/COP
activities refer to activities initiated by an officer rather than
directed by the dispatching center. It is important to note that
the distinction between reactive and self-initiated/COP activities
is not determined by what is done but rather by the manner in which
the activity is **initiated.** As an example, if an officer is
directed to a particular location to control traffic because of a
fallen tree on the roadway, the time spent on this activity would
be charged to reactive time. If, on the other hand, the officer
discovers the fallen tree while on uncommitted patrol and deter-
mines that he/she should control traffic until the tree can be
removed from the roadway, this time would be assigned to the
self-initiated/COP category. Table 1 indicates that three field
test agencies determined the average self-initiated time by policy
 (Section **4.1),** but none of agencies used the indirect policy method
based on a specified number of contacts per shift and the average
time per contact (Section **4.2).** When based solely on historical
data (Section **4.3),** the average value was **8.57** minutes per hour per
officer.

   Service time. Average service times for accidents and other **CFS**
are used in Worksheet 3 to determine the average number of on-duty
officers needed each day to handle the **"obligated"** workload.
Service time refers to the total spent on an incident by all agency
patrol personnel. Service times should include:

- travel time (not including dispatching time),

- on-scene time,

- report writing time,

- investigation time (by patrol),

- processing time (e.g., for **DUIs),** and

- time spent by backup units.

In Table **1,** the average service times for accidents and other **CFS** are **1.57** and **0.81** hours respectively.   Few agencies have data collection procedures that capture all the components of service time listed above. Many CAD systems, for example, will capture the travel, on-scene, and possibly some follow-up time of the primary unit dispatched to an incident, but may not capture report writing time and time spent by backup units.   Some agencies do not routinely record the frequency and amount of time spent by backup units although such time may represent a significant part of the total obligated time for an agency.   If an agency plans to use data from a CAD system, it is recommended that the data definitions in the system be examined to detect shortcomings in the statistics produced by the system.   Recognizing that few agencies routinely capture all the components of service time, it is likely that most users will have to estimate part of the average **service** times. Reliable estimates for average service times do not require that information be obtained from all incidents.   (In **fact,** this is not realistic since incident records are often incomplete.) A reliable estimate for the average service time for an incident category can be obtained using a random sample of **100** or more incidents in the category for the time period of interest.

In Worksheet **3,** total obligated time is determined first by calculating the total obligated time required for all accidents and then using that time to determine the total number of on-duty officers needed each day for accidents (Section **3.1).** The same procedure is used in Section **3.2** to determine the total number of on-duty officers required each day to handle all other **CFS.** The results are then added together in Section **3.3** to obtain the total number of on-duty officers needed each day for both accidents and other **CFS.** The PAM model separates accidents and other **CFS** to enable the user to identify the number of officers required for each type of incident.

During the field tests, some agencies did not use both categories in Worksheet **3,** but decided instead to group all incidents in the other **CFS** category.   This procedure will yield the same total number of on-duty officers if an adjusted average service time based on both types of incidents is used.   It is also possible to use more than two categories.   For example, the **"Other CFS"** category can be divided into several subcategories, and each subcategory can be used to determine the number of on-duty officers that are needed each day to handle all calls in that subcategory. (To use this procedure, however, requires an estimated average service time for each subcategory.)   The total number of officers required is **obtained by** adding the officer requirements for each subcategory.   While the use of subcategories provides additional information about which types of incidents require the most

personnel, it has no impact on the total staffing level required for all incidents. As a result, the value of the additional information must be weighed against the extra effort required to collect incident data and to estimate a service time for each subcategory.

Shift length. The PAM procedures are designed to accommodate any shift length **(e.g.,** 8 hours, **10** hours, or **12** hours). Changes in the shift length will alter the shift relief factor for an agency. For **8-hour** shifts, **SRFs** typically fall into the range: **1.60 - 1.90.** For lo-hour shifts, the range is **2.00 - 2.40;** and for **12-hour** shifts, the usual range is **2.40 - 2.90.** A common misperception is that since a change in the shift length changes the **SRF,** it must change the total staffing requirement for an agency. In fact, if the average work week **(e.g., 40** hours per week) and the total time off given for benefits (e.g., vacations, holidays, etc.) remain the same, a change in shift length has no impact on total staffing.

Special assignment personnel. Special assignment personnel who are also used for patrol can be included in Worksheet **7** of the Manual. The user must provide the total number of officers used for each type of special assignment in the **APA** and the average fraction of time each officer spends on patrol. This information is then used to adjust the total number of @@non-special assignment@@ officers that are needed. The final staffing value from Worksheet 7 includes both special and non-special assignment officers. The PAM model cannot be used to estimate how many officers will be needed for special assignments (e.g., tactical and accident investigation units).

Travel times. In sections **5.3** and **5.4,** the user must provide travel time objectives as part of the procedure for determining how many on-duty officers are needed for response to emergency and **non-**emergency activities. Travel time refers to the time interval that begins when an officer receives a dispatch and ends when he/she arrives on scene. Travel time does not include dispatching time (i.e., the time required at the **communication** center to process and transmit the assignment to the officer). It is also important to note that the travel times required in sections **5.3** and **5.4** are @@averages.@@ This means that the actual travel time will be less than the user-specified average about half of the time and greater than the average for the other half. In Table **1,** the average travel time objective selected during the field test for emergency response was **4.50** minutes.

SECTION **4:** Recommended Data Collection and Implementation
Procedures

Most of the work associated with using the PAM procedures involves
defining and collecting data, and unless caution is exercised, it
is possible to be overwhelmed by these activities. This section of
the Guide presents a recommended procedure for using the model that
is designed to avoid excessive data collection efforts.   The
recommended procedure is based on the successes and problems
encountered by the municipal police departments during the Phase IV
field test.   The procedure consists of four steps that describe an
iterative process for using the PAM model.

STEP **1:** Obtain Initial **Staffing** Level Estimates With Minimum
Data Collection Effort

It is likely that every agency that uses the PAM procedures will
find that it does not have all the input data that is required.
This may occur for several reasons: the agency may not routinely
collect the data; the agency may collect the data, but not in the
form or categories required; or the data may not be stored in an
easily retrievable form.   Whatever the reasons, an agency will be
faced with the question of how much effort to expend in obtaining
each data item.   Step 1 recommends minimizing the initial data
collection effort; that is, for input data items that are not
easily obtained, **"quick** and **dirty"** estimates should be used.   The
rationale for this recommendation is that it is more important to
obtain an initial estimate of the total staff required than it is
to obtain a high level of accuracy for every input data item. It
is strongly recommended that plans for extensive data collection be
deferred until steps 2 and 3 described below are implemented.

STEP **2:**   Assess the Quality of the Input Data Items

After the initial staffing estimates have been obtained, each of
the input data items should be assessed in terms of completeness,
reliability, and accuracy.   The assessment of each item will be a
subjective process. As an example, it may be determined that there
are **68** miles of category 2 roadway miles in an **APA.** If this figure
was obtained from the city street department and is based on recent
data, it is reasonable to conclude that this item is reasonably
accurate.   On the other hand, if the average service time for
handling accidents is based on a survey of three field sergeants
who give individual estimates of **1.1, 2.5,** and **3.2** hours, it would

be clear that further effort is needed to obtain a better estimate. It is recommended that all data items be placed into three or four groups depending on their relative quality (i.e., accuracy, reliability, etc.). Those data items in the lowest category (i.e., least accurate, least reliable, etc.) will be the initial candi-dates for additional refinement.

STEP **3:** <u>Investigate the Sensitivity of the **Staffing** Estimates to Changes in Individual Data Items</u>

The next step is to identify which of the @@soft@@ input data items should be refined. The basis for identifying these items is to determine which items make the biggest contribution to the overall staffing estimate. Not all data items used in PAM are equally important; i.e., not all items have the same impact on the total staffing estimate. For example, in an agency that places a low priority on uncommitted patrol visibility on category 3 roadways (i.e., the patrol interval is very high), it may not be important to have a highly accurate figure for the number of category 3 roadway miles in the **APA** since even a large change in the number of miles will have only a minimal impact on the final staffing estimate.   In contrast, final staffing estimates tend to be sensitive to changes in the shift relief factor; that is, changes of only 5 or **10** percent in the relief factor can produce changes of 5 or **10** percent in the final staffing estimate.   Sensitivity analyses should be done for each data item in the lowest data quality category to identify those items for which additional accuracy is needed and justified.

STEP **4: Improve** <u>Accuracy of Important Data Items</u>

The final step recommends that the input data items targeted for additional refinement be prioritized based on the results of steps 2 and 3 above. Such a list serves two purposes. First, effort can be directed toward those data items that are @@soft@@ <u>and</u> will have an impact on the staffing estimate. Second, limited **resources** can be targeted efficiently.   As each data item is improved, more reliable staffing figures will be generated. This process has no natural termination point, but rather is limited by the resources and time available.   At some point, the effort and resources required to improve the data will outweigh the value gained by the changes in the staffing estimate.

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APPENDIX A: Comprehensive List of Data Requirements for
             Use of the PAM Model

This appendix presents a list of all of the data items that may be used in the PAM model. The list is organized by the worksheet in which each item is first used.

Worksheet **1**:   Operations, Workload, and **Roadway** Data

All data items in Worksheet 1 are required.

Data Item	Worksheet Identifier
Name of the **APA**	**1.1**
Shift length (hours)	**1.2.1**
Average work week (hours)	**1.2.2.1**
Average number of benefit (paid) off-duty hours per year per officer	**1.2.2.2**
Average number of on-duty hours spent on non-patrol temporary assignments per year-per officer	**1.2.2.3**
Average number of officers to be supervised by each field supervisor	**1.2.3**
Percentage of field supervisor on-duty time spent on uncommitted patrol, reactive, and self-initiated/COP activities	**1.2.4**
Type name, category 1 roadways in the **APA**	**1.2.5.1**
Average patrol speed (MPH), category 1 roadways in the **APA**	**1.2.5.2**
Patrol interval performance objective (hours), category 1 roadways in the **APA**	**1.2.5.3**

Data Item	Worksheet Identifier
Type name, category 2 roadways in the **APA**	**1.2.6.1**
Average patrol speed (MPH), category 2 roadways in the **APA**	**1.2.6.2**
Patrol interval performance objective (hours), category 2 roadways in the **APA**	**1.2.6.3**
Type name, category 3 roadways in the **APA**	**1.2.7.1**
Average patrol speed (MPH), category 3 roadways in the **APA**	**1.2.7.2**
Patrol interval performance objective (hours), category 3 roadways in the **APA**	**1.2.7.3**
Total number of days in the workload sample period	**1.3.1**
Total number of accidents handled by the agency during the sample period	**1.3.2**
Average service time (hours) per accident	**1.3.3**
Total number of other **CFS** handled by the agency during the sample period	**1.3.4**
Average service time (hours) per **CFS**	**1.3.5**
Percentage of other **CFS** that cannot be preempted .	**1.3.6**
Percentage of administrative activities that cannot be preempted	**1.3.7**
Percentage of self-initiated/COP activities that cannot be preempted	**1.3.8**
Number of miles, category 1 roadways **in the APA**	**1.4.1**
Number of miles, category 2 roadways **in the APA**	**1.4.2**
Number of miles, category 3 roadways **in the APA**	**1.4.3**

Worksheet 2: <u>Administrative Time</u>

In Worksheet **2,** the user has the option of providing data item **2.1** <u>or</u> data items **2.2.1** and **2.2.2.**

<table>
<tr><td><u>Data Item</u></td><td><u>Worksheet
Identifier</u></td></tr>
<tr><td>Administrative time performance objective
   in minutes per hour per officer . . . .</td><td>**2.1**</td></tr>
<tr><td>Total time (hours) spent on administrative
   activities during the sample period . . . .</td><td>**2.2.1**</td></tr>
<tr><td>Total on-duty hours on patrol
   during the sample period . . . .</td><td>**2.2.2**</td></tr>
</table>

Worksheet 3: <u>Reactive Time</u>

All data items for Worksheet 3 are obtained from Worksheet **1.**

Worksheet 4: <u>Proactive Time – Self-Initiated and **Community-**
                       Oriented **Policing**</u>

In Worksheet **4,** the user has the option of providing data item **4.1** <u>or</u> data items **4.2.1, 4.2.2,** and **4.2.4,** or data items **4.3.1** and **4.3.2.** Input data item **4.5.1** is optional:

<table>
<tr><td><u>Data Item</u></td><td><u>Worksheet
Identifier</u></td></tr>
<tr><td>Self-initiated performance objective time
   in minutes per hour per officer . . . .</td><td>**4.1**</td></tr>
</table>

| | Worksheet |
| Data Item | Identifier |

Total number of self-initiated contacts
  during the sample period **4.2.1**

Total time (hours) spent on self-initiated
  contacts during the sample period **4.2.2**

Number of self-initiated contacts per
  shift per officer performance objective **4.2.4**

Total time (hours) spent on self-initiated
  contacts during the sample period **4.3.1**

Total on-duty hours on patrol
  during the sample period **4.3.2**

Average percent of time per officer to be
  spent on community-oriented policing
  activities **4.5.1**

Worksheet 5: Proactive — Uncommitted Patrol

In Worksheet **5,** the user has the option of providing data item
5.2.4.1 <u>or</u> data items **5.3.2, 5.3.3, 5.3.4,** and **5.4.2, 5.4.3, 5.4.4.**

| | Worksheet |
| Data Item | Identifier |

Performance objective percentage of emergency
  accidents and other **CFS** for which there will
ᴬ be at least one officer available **5.2.4.1**

Area (square miles) Of the **APA** **5.3.2.1**

Average response speed (MPH) for emergency
  reactive activities **5.3.2.2**

Average travel time performance objective
  (minutes) for emergency activities **5.3.2.3**

Area (square miles) of the **APA** **5.4.2**

Data Item	Worksheet Identifier
Average response speed (MPH) for non-emergency reactive activities	**5.4.3**
Average travel time performance objective (minutes) for non-emergency activities	**5.4.4**

Worksheet 6: Average Daily Number of **On-Duty** Officers

In Worksheet **6,** the user can provide data item **6.2.1** or data item **6.3.1.**

Data Item	Worksheet Identifier
Percentage of time patrol units are staffed with **two** officers	**6.2.1**
Average minimum number of on-duty officers required per day for all patrol activities, based on agency policy	**6.3.1**

Worksheet 7: Special Assignments and Field Supervision

In Worksheet **7,** the user has the option of using all, some, or none of **the** data items listed **below.**

Data Item	Worksheet Identifier
Name of special assignment 1	**7.2.1.1**
Average number of on-duty officers on specialized assignment 1	**7.2.1.2**

A - 5

| | Worksheet |
| Data Item | Identifier |

Percentage of on-duty time spent on
  patrol by officers assigned
  to special assignments 1 . . . . **7.2.1.3**

Name of special assignment 2 . . . . **7.2.2.1**

Average number of on-duty officers on
  specialized assignment **2** **7.2.2.2**

Percentage of on-duty time spent on
  patrol by officers assigned
  to special assignments 2 . . . . **7.2.2.3**

Name of special assignment 3 . . . . **7.2.3.1**

Average number of on-duty officers on
  specialized assignment **3** **7.2.3.2**

Percentage of on-duty time spent on
  patrol by officers assigned
  to special assignments 3 . . . . **7.2.3.3**

Worksheet 8: Total Patrol Staff Requirements

In Worksheet **8,** the user may provide data item **8.4.**

| | Worksheet |
| Data Item | Identifier |

Number of command personnel **-** agency policy **8.4**

Worksheet 9: Allocation of Patrol Personnel **Among** Several **APAs**

| | Worksheet |
| Data Item | Identifier |

Total number of additional personnel
  for all **APAs** (enter a negative value
  for personnel reduction) **9.1.1**

Data Item	Worksheet Identifier
Total number of current personnel	**9.1.2**
Number of current personnel in each **APA**	**9.1.3**
Number of personnel estimated for each **APA** by the PAM model	**9.1.5**

Supplemental Worksheet: **Uncommitted Patrol Availability - Immediate Response**

The supplemental worksheet for Section **5.2** is located in Appendix A in the **Manual**.

Data Item	Worksheet Identifier
Percent of on-duty staff on shift 1	**A.2.1**
Percent of on-duty staff on shift 2	**A.2.4**
Percent of on-duty staff on shift 3	**A.2.7**
Percent of accidents on shift 1	**A.3.1**
Percent of accidents on shift 2	**A.3.4**
Percent of accidents on shift 3	**A.3.7**
Percent of other **CFS** on shift 1	**A.4.1**
Percent of other **CFS** on shift 2	**A.4.4**
Percent of other **CFS** on shift 3	**A.4.7**
Percent of non-preemptable other **CFS** on shift **1** ..	**A.5.1.1**
Percent of non-preemptable administrative activities on shift 1	**A.5.1.2**
Percent of non-preemptable self-initiated/COP activities on shift 1	**A.5.1.3**

	Worksheet Identifier
<u>Data Item</u>	
Performance objective percentage of emergency accidents and other **CFS** activities on shift 1 for which there will be at least one officer available	**A.5.4.1**
Percent of non-preemptable other **CFS** on shift 2 . .	**A.6.1.1**
Percent of non-preemptable administrative activities on shift 2 . . . . •	**A.6.1.2**
Percent of non-preemptable self-initiated/COP activities on shift 2	**A.6.1.3**
Performance objective percentage of emergency accidents and other **CFS** activities on shift 2 for which there will be at least one officer available	**A.6.4.1**
Percent of non-preemptable other **CFS** on shift 3 . .	**A.7.1.1**
Percent of non-preemptable administrative activities on shift 3	**A.7.1.2**
Percent of non-preemptable self-initiated/COP activities on shift 3	**A.7.1.3**
Performance objective percentage of emergency accidents and other **CFS** activities on shift 3 for which there will be at least one officer available	**A.7.4.1**

APPENDIX **B:** <u>Glossary and Worksheet Abbreviations and Notation</u>

<u>Glossary</u>

Accident - In PAM, an accident refers to a sequence of events involving one or more vehicles that produces injury, death, or property damage and requires investigative time by one or more officers.

Administrative time - Time spent by patrol personnel on activities other than reactive, self-initiated/COP, or uncommitted patrol. May include supervision, meals, on-duty court time, auto maintenance, training, and agency administrative duties.

Agency policy - The specification of performance objectives for use in the PAM model. (See "Performance Objective.")

Allocation - In the PAM model, allocation refers to the distribution of a specified number of officers over several **APAs.**

Area - The geographic area of the **APA** in square miles. Large areas within the jurisdiction without roads (e.g., lakes, wilderness areas, etc.) should not be included. The area is used to determine the number of officers needed to provide a specified average travel time to accidents and other **CFS.** The value used in the model may include areas outside of the jurisdiction of the agency if passage through these areas is routinely used in responding to accidents and other **CFS.**

Area patrol - Patrol assignment which includes responsibility for both traffic services and general police response within a specified geographic area. (See "Line Patrol.")

Arterial roadway - A major **"through"** roadway that is typically used to travel longer distances within a community or region. In cities, most arterial roadways have considerable commercial development and are part of the state's numbered roadway **system.**

Autonomous patrol area **(APA)** - Patrol area in which one or more officers are assigned which has the following characteristics: **(1) CFS** may be assigned to any of the officers in the **APA, (2) CFS** are rarely dispatched to officers assigned outside of the **APA,** and **(3)** officers assigned to the **APA** rarely respond to **CFS** outside of the **APA.**

Availability - In the PAM model, one criterion for determining the number of officers required for uncommitted patrol is based on an analysis of the number of officers that must be **"available"** in order to meet two performance standards: **(1)** the likelihood or probability (set by the user) that at least one officer will be available for immediate dispatch to a **CFS,** and **(2)** that enough officers will be available to insure that a specified average travel time (set by the user) will be met.

Average work week - The average number of paid on-duty hours per officer per week.

Backup unit - A patrol unit that is assigned or responds to a **CFS** to assist the primary unit.

Benefit days off - Paid time off taken by officers in addition to regular days off provided by the work schedule. Benefit time off includes vacation leave, sick leave, holidays, and compensatory time off.

CFS - **CFS** stands for **"calls** for service" (i.e., calls to the police agency that require the dispatch of one or more officers). The PAM model uses the total time required to service **CFS** as the workload measure for reactive time. For agencies with full police powers, **CFS** include criminal activities, traffic accidents, and various other police services. Some agencies may limit their reactive time to **CFS** that consist primarily of traffic accidents and assistance to motorists and other agencies.

Citation - A summons or notice to appear issued by an officer for a traffic law violation.

Collector roadway - An "intermediate" roadway that is used by
   motorists as a bridge between residential and arterial
   roadways. Collector roadways often have mixed commercial
   and higher density residential development.

Command personnel - Those personnel assigned to an **APA**
   or several **APAs** who provide support services (e.g., train-
   ing, range, or desk officers) and the command staff above
   the rank of field supervisor.

Community-oriented policing (COP) - A patrol philosophy which
   encourages or requires police officers to park their
   vehicles and walk in the community and interact with
   residents. While doing this, the officers are generally not
   assigned calls for service. Some agencies have policies
   specifying the amount of time patrol officers should spend
   on COP activities. Other agencies use assigned officers for
   this task and patrol officers are not normally involved.

Compensatory time off - Time off granted in lieu of monetary
   payment for overtime work. Compensatory time or **"comp time"**
   may be granted at different rates. A straight time rate
   implies that one hour of **comp** time is given for each hour of
   overtime worked. A **comp** time rate of time and a half
   implies that 1 **1/2** hours of **comp** time is granted for each
   hour of overtime.

Constrained allocation - Constrained allocation refers to the
   distribution of a specific number of officers over several
   APAs with limitations on the number of officers that can be
   assigned to each **APA.** In the PAM model, constrained
   allocation is used for two cases: **(1)** when a specific number
   of officers are to be added to an existing allocation, the
   constrained allocation will determine a new allocation of
   the existing and new officers with the limitation or
   "constraint" that the revised staffing level for each **APA**
   must equal or exceed the existing level for each **APA,** and
   (2) when a specific number of officers are to be subtracted
   from an existing allocation, the constrained allocation will
   determine a new allocation of the reduced number of officers
   with the limitation or constraint that the revised staffing
   level for each **APA** must not exceed the existing staffing
   level for each **APA.** (See **"Unconstrained Allocation."**)

Contacts - In the PAM model, contacts refers to self-initiated activities. One measure of the level of self-initiated activity is a count of the number of self-initiated contacts (i.e., the number of stops for traffic violations, warnings, and assists) per hour per shift.

Controlled-access highway - A roadway in which owners or occupants of abutting lands have no legal right of access to or from the roadway except at such points only and in such manner as may be determined by the public authority having jurisdiction over the roadway (e.g., most interstate highways).

Deployment plan - A generic term that refers to the resource allocation staffing plan for an agency. A comprehensive deployment plan may indicate the level of staff resources that are needed and how those resources should be allocated by time **(e.g.,** by time of day and day of the week) and by geography **(e.g.,** by **APA).**

Deterrence - The impact of visible patrol units on potential traffic and criminal offenders. (See @@Preventive Patrol.@@)

Dispatching time - The time interval that begins when a call is received at the dispatching center and ends when the assignment is communicated to an officer.

Dispatched unit - A patrol unit that is assigned to a **CFS** by the dispatching or telecommunication center.

Emergency activity - An accident or other **CFS** for which an immediate response is required.

Field supervisor - Field supervisor refers to agency personnel who provide on-the-road supervision of patrol officers. Typically, field supervisors hold the rank of corporal, or sergeant.

Follow-up investigation - Investigation of an incident after the initial on-scene investigation.

Fraction — In the PAM model, a fraction refers to a number between zero **(0)** and one **(1).** A fraction can be converted to a percentage by multiplying it by **100.** For example, a fraction of **0.5** is equivalent to **50%** (i.e., **100** x **0.5 = 50).**

Full-time — In PAM, the term @@full-time" is used to refer to officers and field supervisors who are assigned exclusively to patrol. Officers who work on non-patrol units or have permanent special assignments are not @@full-time@@ on patrol.

Historical experience — Refers to the derivation of a value in the PAM model based on data from the past experience of an agency.

Immediate response — An agency provides an @@immediate response@@ to a **CFS** when the assignment is dispatched as soon as it is received at the dispatching center <u>and</u> the assigned unit begins travel to the scene as soon as it receives the assignment. (See @@Probability of Immediate Response.@@)

Interstate highway — A roadway identified by the Federal government as part of the U.S. National Interstate and Defense Highway system. Interstate highways must conform to a number of design requirements (e.g., they must be limited access roadways) and are designated by red and blue identification shield-shaped signs.

Jurisdiction — The entire area in which an officer has law enforcement powers.

Model — The PAM model is a systematic procedure for representing the relationships between the patrol staff requirements for municipal police departments and a number of workload, operational, and policy descriptors.

Moving patrol — Uncommitted patrol time during which a patrol vehicle is moving with the normal flow of traffic. (See @@Stationary Patrol.@@)

Non-emergency activities — Accidents and other **CFS** for which an immediate response is not required.

Non-patrol time – In PAM, @@non-patrol time@@ refers to on-duty
time spent on special assignments.

Non-preemptable activities – Officers assigned to a **non-pre-
emptable** administrative, reactive, or self-initiated/COP
activity cannot be reassigned until he/she has completed
his/her current assignment or he/she is relieved by another
officer. Examples of non-preemptable activities are
testifying in court, clearing accidents with roadway
blockage, or taking serious incident reports.

Non-permanent assignment – A temporary special assignment.
Temporary special assignments that require one or more
shifts (e.g., protection of a visiting dignitary) are
usually included in the calculation of the shift relief
factor for the agency. Temporary special assignments that
require less than one shift are included in the @@adminis-
trative@@ time category. (See @@Special Assignments.@@)

Non-supervisory work – Work done by a field supervisor that does
not involve the supervision of subordinates. Non-supervis-
ory work usually includes patrol activities that could be
performed by officers.

Obligated time – The total time required by patrol units to
respond to and service **CFS.** Obligated time includes the
travel time, on-scene time, report writing time, and
follow-up investigation time expended by all patrol units
that respond to a **CFS.** In the PAM **model, total** obligated
time is based on the time spent by each unit, not each
officer. Total obligated time serves as the **workload**
measure to determine the number of patrol units required for
reactive time activities. Total obligated time is also
referred to as total service time or total reactive time.

Officers – A generic term that refers to sworn personnel in a law
enforcement agency.

On-duty time - In the PAM model, on-duty time refers to the
     actual time that an officer <u>appears </u>for work. On-duty time
     includes both patrol time and non-patrol time. Non-patrol
     time includes time spent on temporary special assignments.
     On-duty time can be determined by assuming that an officer
     works every day and subtracting the number of days that an
     officer is off duty for both scheduled time off (i.e.,
     regular days off) and benefit time off (i.e., vacation time,
     holidays, sick leave, etc.). If this method is used, paid
     overtime must be added to determine the total on-duty time.

One-officer unit - A patrol unit with only one officer assigned
     to it.

Patrol activity - A generic term that refers to the activities
     included in the four time categories used in the PAM model
     (i.e., reactive, self-initiated/COP, uncommitted patrol, and
     administrative).

Patrol area - See @@Area."

Patrol contacts - Used in the PAM model to refer to incidents
     included in the @@self-initiated@@ category (e.g., an officer
     who issues four citations and assists two motorists during
     one shift would have had six contacts).

Patrol interval - A measure of the extent or intensity of patrol
     coverage. The patrol interval is defined as the frequency
     with which an officer will pass a given point on the roadway
     or the average time a stranded motorist would have to wait
     for an officer to come by on uncommitted patrol. Patrol
     interval is determined by the number of roadway miles, the
     number of patrol units, the amount of uncommitted patrol
     time per hour per unit, and the average patrol speed.

Patrol speed - The average speed in miles per hour of a unit
     while on uncommitted patrol. The speed can be determined by
     dividing the miles driven per shift by uncommitted patrol
     time, The total miles should <u>not</u> include miles driven while
     responding to an accident **or other CFS,** or performing an
     administrative activity. Uncommitted time does not include
     time spent on administrative, reactive, or self--
     initiated/COP activities. The time spent on uncommitted
     patrol should include time spent on both moving and station-
     ary patrol.

Patrol unit – A vehicle used by one or two officers for patrol
activities. In the PAM model, the procedures used in
worksheets 2 – 5 and Section **6.1** in Worksheet 6 are based on
the assumption that each patrol unit has one officer. As a
result, in these worksheets, the terms @@number of patrol
units@@ and @@number of officers on patrol@@ are used inter-
changeably. (An adjustment for the use of two-officer
patrol units is presented in Worksheet **6.)**

Performance objective – A target or specified performance
standard that is set either by policy or by historical
experience. In the PAM model, performance objectives may be
set for **(1)** the number of minutes per hour per officer
spends on administrative activities, **(2)** the number of
minutes per hour per officer spends on self-initiated/COP
activities, **(3)** the number of self-initiated contacts per
shift per officer, **(4)** the average patrol interval, **(5)** the
percentage of accidents and other **CFS** for which an officer
can be dispatched immediately, **(6)** the average travel time
to accidents and other **CFS, (7)** the percentage of two-off-
icer units, **(8)** the average number of officers per field
supervisor, and **(9)** the number of command personnel re-
quired.

Permanent assignment – An assignment that will continue for an
indefinite period of time. In PAM, the adjustment for the
number of officers required for patrol when some officers
are on permanent special assignment is covered in
Worksheet **7.**

Preemptable activities – Officers assigned or engaged in
preemptable administrative, reactive, or self-initiated/COP
activities can be interrupted and immediately reassigned to
a more serious or emergency incident. Preemptable activi-
ties include service calls, post-incident report writing,
traffic stops, and meal breaks.

Preventive patrol – Visible uncommitted patrol designed to
prevent or limit unlawful activity. (See @@Deterrence.@@)

Primary highway – A U.S. or state-numbered route, or other major
highway designated by authorities as part of a major system
of roadways within their jurisdiction.

Primary unit - Patrol unit that is assigned to or initiates a patrol activity and has responsibility for investigating and reporting the activity.

Proactive time - Proactive time refers to time spent by an officer on self-initiated/COP activities and uncommitted patrol; it includes the time spent performing the activity **(e.g.,** issuing a citation) and the time spent on uncommitted patrol looking for the activity (e.g., looking for traffic violators).

Probability of immediate response - The probability that when the next **CFS** arrives, at least one officer will be free or available for assignment to the call.

Queuing theory - A branch of mathematics that uses statistics and probability to describe the operating characteristics of queues (i.e., waiting lines). The receiving and assigning of **CFS** at a police dispatching center can be viewed as a waiting line operation in which **CFS** represent customers who will have to wait in line (i.e., stacked) if all servers (i.e., patrol units) are busy. The determination of the @@probability of immediate response@@ in the PAM model is based on formulas derived from queuing theory.

Reactive time - The total time required by all patrol units to respond to and handle a **CFS.** (See @@Obligated Time.@@)

Reallocation - In PAM, the term @@reallocation@@ is used to identify or distinguish a revised allocation of a specific number of officers over several **APAs** from the original or initial distribution of the officers.

Regular duty - The usual or permanent assignment for an officer or field supervisor. Regular duty may consist of patrol **duty,** special assignment, or a combination of both. An officer is not on regular duty while on temporary assignment.

Residential roadway - A roadway not generally used by through traffic usually located in areas with low-density residential housing.

Response speed - The average speed in miles per hour of a patrol unit responding to an accident or other **CFS.**

Resource allocation - In PAM, resource allocation refers to the determination of the number and allocation of law enforcement personnel whose primary mission is the delivery of police traffic services.

Roadway - A generic term used in PAM to refer to any type of highway or street patrolled by a jurisdiction-wide law enforcement agency **(e.g.,** interstate highways, primary highways, secondary highways, arterial streets, collector streets, residential streets, etc.)

Sample period - In PAM, the sample period refers to the time period for which data is collected. It is not necessary that all input data used in the PAM model be obtained from the same **"sample** period.@@

Secondary highway - Any non-arterial or rural roadway.

Self-initiated activities - Activities carried out by patrol officers that are not assigned by a dispatcher. Examples include most traffic enforcement and motorist assists.

Self-initiated contact - See @@Contacts,@@

Service time - The total time expended by a patrol unit to handle an accident, **CFS,** or self-initiated/COP activity. Service time includes travel time (for dispatched calls), on-scene time, report writing time, and follow-up investigation time expended by all units that provide service. Service time does not include dispatching time. Service time spent on dispatched calls is used to determine the total obligated time for an agency. (See **"Obligated** Time.@@)

Service-on-demand - A term used to characterize **CFS** in order to distinguish them from self-initiated/COP activities.

Shift - An officer's regular on-duty period; sometimes called a tour or watch.

Shift length - The length in hours of each tour, watch, or shift.

Shift relief factor - The shift relief factor indicates the average number of personnel needed to provide one on-duty officer for one shift every day. Shift relief factors for agencies with eight-hour shift lengths are usually between **1.6** and **1.9.** The shift relief factor is multiplied by the average number of on-duty personnel required per day to determine the total patrol staff size. Shift relief factors depend on the shift length, average work week, benefit time off policies of the agency, and the amount of on-duty, non-patrol time per officer.

Special assignments - Additional assignments given to patrol personnel (e.g., accident reconstruction and hazardous materials). Permanent special assignments are handled in Worksheet 7 of the Manual. Time spent on temporary special assignments that last for more than one shift are not included in any of the four patrol time categories **used in** the PAM model, but are accounted for in the determination of the shift relief factor. Time spent on temporary special assignments that require less than one shift is included in administrative time.

Staff - The PAM model uses the term @@staff@@ to refer to the total number of sworn personnel (both on- and off-duty) that are required to provide a specified number of on-duty officers per day.

Stationary patrol - Uncommitted patrol time in which the patrol vehicle is not in motion. Examples include running stationary mode radar and observing an intersection or high accident location for traffic violators.

Temporary assignment - See @@Non-Permanent Assignment.@@

Tour - See @@Shift.@@

Travel time — The time interval that begins when a patrol unit receives a **CFS** assignment from a dispatcher and ends when the unit arrives on scene.   Travel time does not include dispatching time.

Two-officer unit — A patrol unit with two officers assigned to it.

Uncommitted patrol — Time spent by patrol personnel on activities other than reactive, self-initiated/COP, or administrative. Uncommitted patrol time is used to provide agency visibility for the deterrence of traffic violators and agency avail- ability for reactive and self-initiated/COP activities.

Uncommitted time — See @@Uncommitted Patrol Time.@@

Unconstrained allocation — Unconstrained allocation refers to the distribution of a specific number of officers over several **APAs** with no limitations on the number of officers that can be assigned to each **APA.**   (See @@Constrained **Allocation.")**

Uniform staffing — Uniform staffing by shift or **APA** refers to an allocation in which the same number of patrol officers is assigned to each shift, day of the week, or **APA.**

Visibility — One purpose of uncommitted patrol is to promote the general deterrence of traffic and criminal violators by maintaining **a** high level of officer visibility.

Watch — See @@Shift.@@

Work activity — See @@Patrol Activity.@@

Workload — In the PAM model, the term workload refers to the total obligated time generated by all accidents and other **CFS,** and the total time required to provide a user- speci- fied level of self-initiated/COP activities.

Worksheet Abbreviations and Notation

APA – Autonomous patrol area.

AWW – Average work week.

CAD – Computer-aided dispatching.

CFS – Calls for service.

COP – Community-oriented policing.

f_{npa} – Fraction of administrative activities that are non-preemptable.

f_{npai} – Fraction of administrative activities that are non-preemptable on shift i.

f_{npi} – Fraction of reactive activities that are **non-**preemptable on shift i.

f_{npr} – Fraction of reactive activities that are **non-**preemptable.

f_{npri} – Fraction of reactive activities that are **non-**preemptable on shift i.

f_{nps} – Fraction of self-initiated/COP activities that are non-preemptable.

f_{npsi} – Fraction of self-initiated/COP activities that are non-preemptable on shift i.

f_{si} – Fraction of on-duty time spent on non-patrol activities by officers assigned to special unit i.

H_b – Average number of benefit (paid) hours off per year per officer.

H_p – Average number of on-duty hours on patrol per year officer per year.

H_t – Total hours required to cover one shift position for one year.

H_{ta} — Average number of on-duty hours on temporary assignments (non-patrol) per officer per year.

H_y — Average number of paid hours of work per year per officer.

IR% — The agency-specified performance objective for the percentage of accidents and other **CFS** for which at least one officer will be available.

IR%i — The agency-specified performance objective for the percentage of accidents, other **CFS,** and self-initiated/COP activities on shift i for which at least one officer will be available.

K_a — Factor used in Section **5.2** based on m_a and m_s. All administrative activities are treated as non-preemptable.

K_{ai} — Factor used for shift i in Appendix A in the Manual based on m_a and m_s. All administrative activities on shift i are treated as **non-**preemptable.

K_{dsa} — Factor used in Section **5.2** in the Manual to estimate the number of officers required to meet the immediate response performance requirement. It is based on K_{nsa} and K_{sa}.

K_{dsai} — Factor used in Appendix A in the Manual for shift i to estimate the number of officers required to meet the immediate response performance requirement. It is based on K_{nsai} and K_{sai}.

K_f — Factor used in Worksheet 7 to adjust the daily number of on-duty officers. Based on the average number of officers that report to each field supervisor and the percentage of time supervisors spend on patrol work.

K_{na} — Factor used in Section **5.2** based on m_a and m_s and adjusted for the fraction of administrative activities that are non-preemptable.

K_{nai} — Factor used in Appendix A in the Manual based on m_a and m_s and adjusted for the fraction of administrative activities that are **non-**preemptable on shift **i.**

K_{ns} −   Factor used in Section **5.2** based on m_a and m_s and adjusted for the fraction of self-initiated activities that are non-preemptable.

K_{nsa} −   Number used in Section **5.2** in the <u>Manual</u> to determine which table to use to estimate the maximum number of officers required to meet the immediate response performance require-ment. Based on m_a, m_s, and the fraction of administrative and self-initiated/COP activities that are non-preemptable.

K_{nsai} Number used in Appendix A in the <u>Manual</u> to determine which table to use to estimate the maximum number of officers required to meet the immediate response performance requirement for shift **i**. Based on m_a, m_s, and the fraction of administrative and self-initiated/COP activities that are non-preemptable on shift **i**.

K_{nsi} −   Factor used in Appendix A in the <u>Manual</u> for shift i based on m_a and m_s and adjusted for the fraction of self-initiated activities that are non-preemptable on shift **i**.

K_s −   Factor used in Section **5.2** based on m_a and m_s. All self-initiated activities are treated as non-preemptable.

K_{sa} −   Factor used in Section **5.2** in the <u>Manual</u> to estimate the number of officers required to meet the immediate response performance re-quirement. It is based on K_{na} and K_{ns} and as-sumes that no administrative or self-initiated activities are preemptable.

K_{sai} −   Factor used in Appendix A in the <u>Manual</u> to estimate the number of officers required to meet the immediate response performance re-quirement on shift **i**. It is based on K_{nai} and K_{nsi} and assumes that no administrative or **self**-initiated **activites** are preemptable on shift **i**.

K_{si} Factor used for shift i in Appendix A in the <u>Manual</u> based on m_a and m_s. All self-initiated activities on shift i are treated as **non**-preemptable.

K_{tt} — Number used in sections **5.3** and **5.4** to de **termine** the number of officers required to meet the travel time performance objective for area patrol. Based on the average response speed and the travel time objective in minutes.

m_a — The average number of minutes per hour per officer spent on administrative time.

m_r — The average number of minutes per hour per officer spent on reactive activities (i.e., dispatched accidents and other **CFS).**

m_s — The average number of minutes per hour per officer spent on self-initiated/COP activities **(e.g.,** traffic citations, traffic warnings, and motorist assists).

MPH — Miles per hour.

N_{air} — Additional number of on-duty officers required each day to meet the immediate response objective,

N_{airi} — Additional number of on-duty officers required each day for shift i to meet the immediate response objective.

N_{airs} — Additional number of on-duty officers required per shift each day to meet the immediate response objective.

N_{ao} — Adjusted average daily number of on-duty officers.

N_{ari} — Adjusted daily number of on-duty officers required for emergency reactive activities on shift **i.**

N_{ars} — Adjusted daily number of on-duty officers required per shift for emergency reactive activities.

N_{asi} — Adjusted daily number of on-duty officers assigned to special assignment **i.**

N_c —   The total number of command staff, both on and off-duty.

N_{ett} —   The actual number of additional officers needed to meet the travel time performance objective for emergency activities. Used in Section **5.3.**

N_{iri} The actual number of additional officers required on shift i to meet the immediate response time performance objective.

$N_{ir\%s}$ —   The actual number of additional officers required per shift to meet the immediate response time performance objective.

N_{maxtt} —   The maximum number of additional officers needed to meet the travel time performance objective for emergency activities. Used in Section **5.3.**

N_{min} —   The average minimum number of on-duty patrol officers required per day.

N_{nett} —   The actual number of additional officers needed to meet the travel time performance objective for non-emergency activities. Used in Section **5.4.**

N_o —   The average total number of on-duty **officers** per day.

N_{os} —   The average number of on-duty field supervisors per day.

N_{ot} —   The average number of on-duty officers per day.

N_p —   The average number of on-duty officers required per day to meet the uncommitted patrol time requirement.

N_r —   The average number of on-duty officers required per **day** to meet the reactive time (service-on-demand) requirement.

N_{ri} — The average number of on-duty officers required on shift i to meet the reactive time requirement.

N_{rs} — The average number of on-duty officers required per shift to meet the reactive time (service-on-demand) requirement.

N_s — The total number of field supervisors, both on and off-duty.

N_{si} — The number of on-duty officers assigned to special unit **i.**

N_t — The total number of patrol officers, both on and off-duty.

N_{tot} — The total patrol staff requirement.

N_{tt} — The total number of additional officers required to meet both travel time performance objectives specified in sections **5.3** and **5.4.**

PAM — Police Allocation Manual.

SRF — Shift relief factor.

TA — The total staff to be added (or subtracted) for the allocation.

TC — The total current staff.

TE — The total staff requirement based on PAM estimates.

T_N — Total overstaffing (or understaffing) based on current staff levels and PAM staff estimates for each **APA.**

APPENDIX **C:** <u>Example Using PAM Worksheets 1 – 9 To Determine
Patrol Staffing **Requirements** and Allocation</u>

<u>Introduction</u>

This appendix illustrates the use of worksheets **1-8** to determine
staffing levels for one **APA** and Worksheet 9 to allocate staff among
three shifts.   The data used for this example are based on
information obtained from the field test agencies during Phase IV
of the PAM project.

The remainder of this appendix is divided into two parts.   The
first presents observations about the example agency and the
particular options used in each worksheet. Comparisons between the
data values used or calculated for the example and the field test
results (shown in Table 1 in the <u>Guide</u>) are also discussed.   The
second part consists of the completed worksheets.

<u>Observations</u>

In the discussion below, references to specific values in the
worksheets are made by identifying the corresponding worksheet step
numbers in parentheses.

Worksheet 1: <u>Operations, Workload, and Roadway Data</u>

The example **APA** covers the entire jurisdiction for a municipal
police department for a city with a population of approximately
100,000.   The agency handled **2,148** accidents **(1.3.2)** and **45,284**
other calls-for-service **(CFS)(1.3.4)** last year.   The jurisdiction
has **75** miles of arterial streets **(1.4.1), 100** miles of collector
streets **(1.4.2),** and **267** miles of residential streets **(1.4.3).** A
patrol interval of 2 hours is used for arterial streets **(1.2.5.3),**
8 hours for collector streets **(1.2.6.3),** and **48** hours **(1,2,7,3)** for
residential streets.

Worksheet 2: <u>Administrative Time</u>

The agency uses historical data in Section **2.2** to determine that
the administrative time per hour per officer is **12.00** minutes
(2.2.4). The field test average for Section **2.2** was **12.57** minutes.

Worksheet 3: <u>Reactive Time</u>

The total obligated time per day for the agency is **108.49** hours
(3.3.1) which consists of **9.24** hours for accidents **(3.1.5)** and
99.25 hours for all other **CFS (3.2.5)**. Based on an **8-hour** shift,
this level of workload requires **13.56** on-duty officers per day
(3.3.3). The average service time for accidents is **1.57** hours
(3.1.2) which equals the field test average. The average time of
0.80 hours for all other **CFS (3.2.2)** is almost equal to the field
test average of **0.81** hours.

Worksheet 4: <u>Proactive Time - Self-Initiated</u>

The agency determines self-initiated time based on the historical
experience of the agency in Section **4.3.** The average of **8.40**
minutes per hour per officer **(4.3.4)** is slightly lower than the
field test average of **8.57** minutes.

Worksheet 5: <u>Proactive Time - Uncommitted Patrol</u>

In Section **5.1,** the agency calculates a requirement of **7.88** on-duty
officers per day **(5.1.5)** to provide the desired level of patrol
visibility. The **7.88** officers consist of **4.69** officers for
arterial streets **(5.1.2.5)** to meet a **2-hour** patrol interval
objective **(5.1.2.4)**, 2.08 officers for collector streets **(5.1.3.5)**
to meet an **8-hour** patrol interval objective **(5.1.3.4)**, and **1.11**
officers for residential streets **(5.1.4.5)** to meet a **48-hour** patrol
interval objective **(5.1.4.4)**.

For patrol availability, the agency examines two options: the
immediate response option in Section **5.2** and the travel time option
in sections **5.3** and **5.4**. In Section **5.2,** values of **12.00** minutes
for m_a **(5.2.2.8)**, **11.40** minutes for m_s **(5.2.2.9),** and the fractions
of non-preemptable reactive **(5.2.2.5)**, administrative **(5.2.2.6),**
and self-initiated **(5.2.2.7)** activities are used to calculate a
value of **0.10** for K_{nsa} **(5.2.2.15)**. This value indicates that Table
A-2 (5.2.3) should be used to determine the total number of
officers needed per shift to meet the immediate response require-
ment. Based on the immediate response performance objective
(5.2.4.1), the agency determines that a total of **1.90** on-duty
officers **(5.2.4.2)** are needed per shift to insure that at least one
officer will be immediately available for **80%** of the accidents,
other **CFS,** and self-initiated activities. Adjusting for officers
who are @@available@@ on preemptable activities, the negative value
obtained in Step **5.2.4.4** indicates that no additional officers are

needed.   This is shown by the zeroes entered for steps **5.2.4.5** and **5.2.4.6.**   Since the agency has uniform staffing over the 3 shifts, there is no need to use the supplement worksheet in Appendix A (not shown) in place of Section **5.2.**

In Section **5.3,** the daily on-duty staffing for response to emergency activities is determined.   The agency provides around-the-clock coverage over the entire jurisdiction **(36** square miles, **(5.3.2.1))**. Based on an average response speed of **38** miles per hour **(5.3.2.2)**; a target travel time of **4.5** minutes **(5.3.2.3)**; and the fractions of reactive **(5.3.3.3)**, administrative activities **(5.3.3.4)**, and self-initiated activities **(5.3.3.5)** that are not preemptable, no additional officers are required for response to emergency activities **(5.3.4).**

In Section **5.4,** the daily on-duty staffing for response to **non**-emergency activities is determined.   Based on an average response speed of **20** miles per hour **(5.4.3)** and a target travel time of **30.0** minutes **(5.4.4),** **0.48** additional officers are required **(5.4.5.3).**

To determine the number of officers for availability, the agency first determines the number of officers required per day **(5.5)** to satisfy the response time objectives in sections **5.3** and **5.4.** Next, the result in **(5.5)** is compared with the result of Section **5.2 (5.2.4.6)** and the larger value is selected for **(5.6).**   In the example, the larger value is the travel time result of **0.48** officers.   The last step is to determine the number of on-duty officers for uncommitted patrol **(5.7).** This is done by comparing the number of on-duty officers needed for @@visibility@@ (i.e., **7.88** officers in Step **5.1.5)** with the number of officers needed for @@availability@@ (i.e., **0.48** officers in Step **5.6)** and selecting the larger value.   For this example, the number of officers for uncommitted patrol is **7.88** (Step **5.7).**

Worksheet 6:   Average Daily Number of On-Duty Officers

The agency uses Section **6.1** to determine that **35.16** on-duty officers **(6.1.5)** will be needed each day.   Since no patrol units are staffed with two officers, no adjustment is needed for Step **6.2.4.**   The agency has a minimum staffing requirement of **15** officers per day **(6.3.1).**   Since the daily number of officers **(6.2.4)** exceeds the minimum daily requirement, **35.16** officers is entered for Step **6.3.2.**

Worksheet 7:   **Special** Assignment and Field Supervision

Worksheet **7** is used to adjust the number of officers for patrol work performed by field supervisors and officers on special

assignment. For the example, each field supervisor is responsible for an average of 6 officers **(7.1.1)** and spends approximately **25%** of his/her time on patrol (i.e., non-supervisory) activities **(7.1.2).** In Section **7.1,** the agency determines that the adjusted number of on-duty, full-time officers is **33.75 (7.1.6).**

The agency uses an average of 3 officers **(7.2.1.2)** on-duty each day for traffic enforcement-radar activities. Each officer assigned to the unit spends approximately **50%** of his/her time on patrol **(7.2.1.3).** The adjusted number of on-duty officers is **1.44 (7.2.1.6).**

The agency uses an average of 2 officers **(7.2.2.2)** on-duty each day for crime prevention activities. Each officer assigned to the unit spends approximately **30%** of his/her time on patrol **(7.2.2.3).** The adjusted number of on-duty officers is **1.34 (7.2.2.6).**

The total adjusted daily number of on-duty officers equals **36.53 (7.2.4).** The number of on-duty, full-time officers can be obtained by subtracting the total number of special assignment staff on duty each day (i.e., 5 officers, 3 for traffic enforcement and 2 for crime prevention) from the total adjusted number of officers found in Step **7.2.4** (i.e., the number of on-duty, full-time officers equal **31.53 (36.53 – 5)).**

The total number of on-duty field supervisors required per day is **6.09 (7.3.1).** This value is obtained by dividing the adjusted number of on-duty officers **(7.2.4)** by the average number of officers that report to each supervisor **(7.1.1).**

Worksheet 8: <u>Total Staff Requirement</u>

Since the agency has an average work week of **40** hours **(8.2.3),** the average number of paid hours of work per year per officer is **2,085.71 (8.2.4).** When non-patrol time for benefit time off **(8.2.5)** and temporary special assignments **(8.2.6)** are subtracted, the **average** number of patrol hours per year per officer equals **1,671.81 (8.2.7).** The shift relief factor for the agency is **1.747 (8.2.8).** Multiplying the on-duty officer and field supervisor estimates by the shift relief factor yields the total staff requirements (i.e., **63.81** officers **(8.3.1)** and **10.63** field supervisors **(8.3.2)).**

The agency uses Section **8.4** to specify a total of 6 staff and command personnel. The total staff requirement of **80.44** officers for the **APA** is recorded in Section **8.5.**

Worksheet 9: Allocation of Patrol Personnel Among Several shifts

Only Table **4-1** from Worksheet 9 is shown below to illustrate the
allocation procedure. The allocation example is based on 3 shifts.
The current staffing levels for each shift are shown in column **1.**
The sum of column 1 indicates that the total current staffing **(TC)**
is **72** officers.   The PAM staffing estimates for each shift are
shown in column **2.**   (The derivations of these estimates are not
shown.)   The sum of column 2 indicates that the total staff
estimate **(TE)** for the 3 shifts from the PAM model is **80.54**
officers. Comparison of the columns 1 and 2 indicates that shifts
2 and 3 are understaffed. For the example allocation, 6 additional
officers **(TA)** are to be added to the current staffing total of **72.**

The values for the unconstrained allocation of the **78** officers
(i.e., **72** + **6)** are shown in column **3.** (See Step **9.1.7** in Worksheet
9 for the formula used to determine the values in column **3.)**

Columns 4 - 8 are used to determine the constrained allocation of
the **78** officers.   The difference between the values in columns 1
and 3 for each **shift** are shown in column **4.**   The difference
indicates the amount of over or understaffing for each shift.
(Only shift 1 has a positive value which indicates it is overstaff-
ed.)   Since the total staff is to be increased (i.e., **TA > 0),** the
procedures described in Step **9.2.3** are used to determine the values
in column **5.** (For each shift, if the value in column is negative,
it is copied in column **5.** If the value in column 4 is positive, a
zero is entered in column **5.)** Step **9.2.3.3** is used to calculate
how the 6 new officers will be distributed over the 3 shifts
(column **6).** For the constrained allocation procedure, additional
staff is only added to shifts that are understaffed (i.e., shifts
that have negative values in column **5).** The values in column 6 are
rounded to whole numbers and entered column **7.**   (The sum of the
values in column 7 must equal the number of staff to be added.)
The final value for each shift for the constrained allocation,
shown in column **8,** is obtained by adding the current staff (column
1) to the staff to be added (column **7).**   Note that even though
officers are only added to shifts 2 and **3,** Shift 1 remains
overstaffed.

WORKSHEET **1:** Operations, Workload, and Roadway Data

Objective: Identify data items to be used for determining
the number of patrol personnel within an **APA.**

Method: Data is identified as either operations, work-
load, or roadway.

1.1 Autonomous Patrol Area Name .

Law City
(1.1)

1.2 Operations Data for the **APA**

1.2.1 Shift length (hours) . . . .

8.0
(1.2.1)

1.2.2 Average number of on-duty hours on patrol per year
per officer

    1.2.2.1 Average work week (average
number of paid hours per
week per officer) . . . . .

40.0
(1.2.2.1)

    1.2.2.2 Average number of benefit
(paid) off-duty hours per
year per officer . . . . .

275.2
(1.2.2.2)

1.2.2.3 Average number of on-duty
hours spent on non-patrol
temporary assignments per
year per officer . . . . .

> **138.7**

(1.2.2.3)

1.2.3 Average number of officers
to be supervised by each
field supervisor . . . .

> **6.0**

(1.2.3)

1.2.4 Percentage of field supervisor
on-duty time spent on uncommitted
patrol, reactive, and **self-**
initiated/COP activities . . . . .

> **25.0**

(1.2.4)

1.2.5 Patrol operations - roadway category 1

1.2.5.1 Category 1
roadway type . .

> Arterial Streets

(1.2.5.1)

1.2.5.2 Average uncommitted
patrol speed (MPH) . . . .

> **24.0**

(1.2.5.2)

1.2.5.3 Patrol interval
performance objective
(hours) . . . .

> **2.0**

(1.2.5.3)

1.2.6 Patrol operations - roadway category 2

1.2.6.1 Category 2
roadway type . .

> Collector Streets

(1.2.6.1)

1.2.6.2 Average uncommitted
patrol speed (MPH) . . . .

> **18.0**

(1.2.6.2)

C - 7

1.2.6.3 Patrol interval
performance objective
(hours) . . . .

8.0

(1.2.6.3)

1.2.7 Patrol operations - roadway category 3

1.2.7.1 Category 3
roadway type . .

Residential Streets

(1.2.7.1)

1.2.7.2 Average uncommitted
patrol speed (MPH) . . . .

15.0

(1.2.7.2)

1.2.7.3 Patrol interval
performance objective
(hours) . . . .

48.0

(1.2.7.3)

1.3 Workload Data for the **APA**

1.3.1 Total number of days in
the sample period . . . .

365.0

(1.3.1)

1.3.2 Total number of accidents
handled by the agency during
the sample period . . . .

2,148

(1.3.2)

1.3.3 Average service time (hours)
per accident . . . .

1.57

(1.3.3)

1.3.4 Total number of other **CFS**
handled by the agency during
the sample period . . . .

45,284

(1.3.4)

C - 8

1.3.5 Average service time (hours)
per other **CFS** . . . .

0.80

(1.3.5)

1.3.6 Percentage of other **CFS**
that cannot be preempted . . . . .

20.0

(1.3.6)

1.3.7 Percentage of administrative
activities that cannot be
preempted . . . .

12.0

(1.3.7)

1.3.8 Percentage of self-initiated/COP
activities that cannot be
preempted . . . .

20.0

(1.3.8)

1.4 Roadway Data for the **APA**

1.4.1 Roadway category 1 (miles) . . . .

75.0

(1.4.1)

1.4.2 Roadway category 2 (miles) . . . .

100.0

(1.4.2)

1.4.3 Roadway category 3 (miles) . . . .

267.0

(1.4.3)

WORKSHEET **2:** <u>Administrative Time</u>

<u>Objective</u>: Determine the average number of minutes per hour per officer to be spent on administrative activities within the **APA (m_a).**

<u>Method</u>: Based either on policy decision or historical experience.

OPTION: Complete Section **2.1** <u>or</u> Section **2.2.**

═══════════════════════════════════════

2.1 Average Number of Minutes Per Hour Per Officer — Policy Decision

Select administrative time
performance objective in minutes
per hour per officer . . . .

(2.1)

Continue with Section **2.3.**

───────────────────────────────────────

OR

───────────────────────────────────────

2.2 Average Number of Minutes Per Hour Per Officer — Historical Experience

    2.2.1 Total time (hours) spent on
administrative activities within
the **APA** during the sample period .

23,420.0

(2.2.1)

2.2.2 Total on-duty hours on patrol
within the **APA** during the
sample period . . . . | **117,100.0** |

(2.2.2)

2.2.3 Fraction of time spent on
administrative activities,
divide: **(2.2.1) ÷ (2.2.2)** . . . . | **0.20** |

(2.2.3)

2.2.4 Average number of minutes per
hour per officer, multiply:
(2.2.3) x 60 . . . . | **12.00** |

(2.2.4)

2.3 Administrative Time

Minutes per hour per officer,
select either **(2.1)** or **(2.2.4)** . . . . . . | **12.00** | **(m$_a$)**
(note: 0 ≤ **m$_a$** < 60)

(2.3)

WORKSHEET **3:** Reactive Time

Objective: Determine the number of officers required to handle accidents and other **CFS** within an **APA** (**N_r**).

Method: Based on the total time required to handle all accidents and other **CFS,** and the shift length.

3.1 Daily Service Time Requirement for Accidents

3.1.1 Total number of accidents within the **APA** during the sample period, use **(1.3.2)** . . . .

| 2,148 |
(3.1.1)

3.1.2 Average service time (hours) for each accident, use **(1.3.3)** . .

| 1.57 |
(3.1.2)

3.1.3 Total obligated time for accidents within the **APA** during the sample period, multiply: **(3.1.1)** x **(3.1.2)** . . . (or enter directly from CAD system)

| 3,372.4 |
(3.1.3)

3.1.4 Total number of days in the sample period, use **(1.3.1)** . . . .

| 365.0 |
(3.1.4)

3.1.5 Average workload per day for accidents (hours), divide: **(3.1.3)** ÷ **(3.1.4)** . . . .

| 9.24 |
(3.1.5)

3.2 Daily Service Time Requirement for Other **CFS**

3.2.1 Total number of other **CFS** within the **APA** during the sample period, use **(1.3.4)** . . . .

| 45,284 |
(3.2.1)

3.2.2 Average service time (hours) for each **CFS,** use **(1.3.5)** . . . .

| 0.80 |
(3.2.2)

3.2.3 Total obligated time for other **CFS** within the **APA** during the sample period, multiply: **(3.2.1)** x **(3.2.2)** . . . (or enter directly from CAD system)

| 36,227.2 |
(3.2.3)

3.2.4 Total number of days in the sample period, use **(1.3.1)** . . . .

| 365.0 |
(3.2.4)

3.2.5 Average workload per day for other **CFS** (hours), divide: **(3.2.3)** ÷ **(3.2.4)** . . . .

| 99.25 |
(3.2.5)

3.3 Total Number of Officers Required per Day for Reactive Time

3.3.1 Total average workload per day within the **APA** (hours), add: **(3.1.5)** + **(3.2.5)** . . . . . .

| 108.49 |
(3.3.1)

3.3.2 Shift length (hours), use **(1.2.1)** . . . .

| 8.0 |
(3.3.2)

3.3.3 Average number of on-duty officers required per day within the **APA** to meet the avg. daily workload, divide: **(3.3.1)** ÷ **(3.3.2)** . . . . .

| 13.56 | (**N**$_r$)
(3.3.3)

WORKSHEET **4:** <u>Proactive Time - Self-initiated and **Community-**</u>
<u>Oriented **Policing**</u>

> **Objective:** Determine the average number of minutes per hour
> per officer to be spent on self-initiated/COP
> activities within the **APA (m_s)**.

> Method: Based either on policy decision or historical
> experience within the **APA.**

OPTION: Complete Section **4.1** <u>or</u> Section **4.2** <u>or</u> Section **4.3.**

> **4.1** Average Number of Minutes Per Hour Per Officer for **Self-**
> Initiated Activities - Policy Decision (Direct)

> > Select self-initiated performance
> > objective for the **APA,**
> > minutes per hour per officer . . . . . .

$$\boxed{\text{---}}$$
(4.1)

> > Continue with Section **4.4**

OR

> **4.2** Average Number of Minutes Per Hour Per Officer for **Self-**
> Initiated Activities - Policy Decision (Indirect)

> > **4.2.1** Total number of self-initiated
> > contacts within the **APA**
> > during the sample period . . . . .

$$\boxed{\text{---}}$$
(4.2.1)

4.2.2 Total time (hours) spent on
self-initiated contacts within
the **APA** by all officers on
patrol during the sample period .

$$\boxed{\text{---}}$$
(4.2.2)

4.2.3 Average time (hours) per
self-initiated contact within
the **APA** during the sample period,
divide: **(4.2.2) ÷ (4.2.1)** . . . . .

$$\boxed{\text{---}}$$
(4.2.3)

4.2.4 Select number of self-initiated
contacts <u>per shift</u> per officer
performance objective . . . . . .

$$\boxed{\text{---}}$$
(4.2.4)

4.2.5 Shift length (hours),
use **(1.2.1)** . . . .

$$\boxed{\text{---}}$$
(4.2.5)

4.2.6 Number of self-initiated
contacts per hour per officer,
divide: **(4.2.4) ÷ (4.2.5)** . . . . .

$$\boxed{\text{---}}$$
(4.2.6)

4.2.7 Self-initiated performance
objective for the **APA** in minutes
per hour per officer, multiply:
60 x **(4.2.3)** x **(4.2.6)** . . . . . .

$$\boxed{\text{---}}$$
(4.2.7)

Continue with Section **4.4**

OR

4.3 Average Number of Minutes Per Hour Per Officer for **Self-**Initiated Activities - Historical Experience

4.3.1 Total time (hours) spent on self-initiated contacts within the **APA** by all officers on patrol during the sample period, (same as **(4.2.2))** . . . .

| 16,394.0 |
(4.3.1)

4.3.2 Total on-duty hours by officers on patrol within the **APA** during the sample period used for **(4.3.1)** . . . .

| 117,100.0 |
(4.3.2)

4.3.3 Fraction of time spent on self-initiated activities within the **APA** during the sample period, divide: **(4.3.1) ÷ (4.3.2)** . . . . .

| 0.14 |
(4.3.3)

4.3.4 Average number of minutes per hour per officer to be spent on self-initiated activities within the **APA,** multiply: **60 x (4.3.3)** . .

| 8.40 |
(4.3.4)

4.4 Proactive Time (Self-Initiated Activities)

Minutes per hour per officer, select either **(4.1)** or **(4.2.7)** or **(4.3.4)** . . .

| 8.40 |
(4.4)

4.5 Proactive Time (Community-Oriented Policing)

Note : If the agency does not identify COP
activities separately, enter zero **(0)**
for Step **4.5.3** and continue with Step **4.6.**

4.5.1 Average percentage of time
per officer to be spent on
community-oriented policing . . .

5.0

(4.5.1)

4.5.2 Fraction of time per hour
per officer to be spent on
community-oriented policing,
divide: **(4.5.1) ÷ 100** . .. . . .

0.05

(4.5.2)

4.5.3 Minutes per hour per officer
to be spent on **community-**
oriented policing, multiply:
60   x   (4.5.2) . . . .

3.0

(4.5.3)

4.6 Proactive Time (Self-Initiated and Community-Oriented
Policing)

Minutes per hour per officer, add:
(4.4) + **(4.5.3)** . . . .

11.40

(m_s)

(4.6)

WORKSHEET **5:** <u>Proactive Time - Uncommitted Patrol</u>

<u>Objective</u>: Determine the number of officers required within
the **APA** to provide an adequate level of visibility
and availability.

<u>Method</u>: Based on: **(1)** the patrol interval, and **(2)** the
probability of immediate response to accidents and
other **CFS** <u>or</u> the average travel time to accidents
and other **CFS.**

5.1 Uncommitted Patrol Visibility

5.1.1 Shift length (hours),
use **(1.2.1)** . . . .

8.0

(5.1.1)

5.1.2 Number of officers needed per day
for uncommitted patrol on category
1 roadways in the **APA**

5.1.2.1 Category 1
roadway type,
use **(1.2.5.1)** . .

Arterial Streets

(5.1.2.1)

5.1.2.2 Miles of roadway,
use **(1.4.1)** . . . .

75.0

(5.1.2.2)

5.1.2.3 Average patrol speed
(MPH), use **(1.2.5.2)** . . .

24.0

(5.1.2.3)

5.1.2.4 Performance objective
patrol interval (hours),
use **(1.2.5.3)** . . . .

2.0

(5.1.2.4)

5.1.2.5 Number of officers required
per day to meet the patrol
interval performance
objective for category
1 roadways in the **APA,**
use the formula below . . .

4.69

(5.1.2.5)

$$
\text{Number of Officers (5.1.2.5)} = \frac{24 \quad \text{x} \quad \substack{\text{Roadway} \\ \text{Miles} \\ \text{(5.1.2.2)}}}{\substack{\text{Average} \\ \text{Patrol} \\ \text{Speed} \\ \text{(5.1.2.3)}} \text{ x } \substack{\text{Shift} \\ \text{Length} \\ \text{(5.1.1)}} \text{ x } \substack{\textbf{Perf.} \text{ Obj.} \\ \text{Patrol} \\ \text{Interval} \\ \text{(5.1.2.4)}}}
$$

―――――――――――――――――――――――――――――――――――――――

5.1.3 Number of officers needed per day
for uncommitted patrol on category
2 roadways in the **APA**

5.1.3.1 Category 2
roadway type,
use **(1.2.6.1)** . .

Collector Streets

(5.1.3.1)

5.1.3.2 Miles of roadway,
use **(1.4.2)** . . . .

100.0

(5.1.3.2)

5.1.3.3 Average patrol speed
(MPH), use **(1.2.6.2)** . . .

18.0

(5.1.3.3)

5.1.3.4 Performance objective
patrol interval (hours),
use **(1.2.6.3)** . . . .

8.0

(5.1.3.4)

5.1.3.5 Number of officers required per day to meet the patrol interval performance objective for category **2** roadways in the **APA,** use the formula below ...

2.08

(5.1.3.5)

Number of Officers **=** (5.1.3.5)

$$\text{Number of Officers (5.1.3.5)} = \frac{24 \times \underset{(5.1.3.2)}{\text{Roadway Miles}}}{\underset{(5.1.3.3)}{\text{Average Patrol Speed}} \times \underset{(5.1.1)}{\text{Shift Length}} \times \underset{(5.1.3.4)}{\textbf{Perf.} \text{Obj. Patrol Interval}}}$$

-- --- - - --- --- --- --- --- --- --- ---

5.1.4 Number of officers needed per day for uncommitted patrol on category 3 roadways in the **APA**

5.1.4.1 Category 3 roadway type, use **(1.2.7.1)** . .

Residential **Steets**

(5.1.4.1)

5.1.4.2 Miles of roadway, use **(1.4.3)** . . . • . . . •

267.0

(5.1.4.2)

5.1.4.3 Average patrol speed (MPH), use **(1.2.7.2)** . . .

15.0

(5.1.4.3)

5.1.4.4 Performance objective patrol interval (hours), use **(1.2.7.3)** . .

48.0

(5.1.4.4)

5.1.4.5 Number of officers required per day to meet the patrol interval performance objective for category 3 roadways in the **APA,** within the **APA,** use use the formula below ...

| 1.11 |

(5.1.4.5)

$$\text{Number of Officers (5.1.4.5)} = \frac{24 \quad x \quad \begin{array}{c}\text{Roadway}\\\text{Miles}\\\textbf{(5.1.4.2)}\end{array}}{\begin{array}{c}\text{Average}\\\text{Patrol}\\\text{Speed}\\\textbf{(5.1.4.3)}\end{array} \quad x \quad \begin{array}{c}\text{Shift}\\\text{Length}\\\textbf{(5.1.1)}\end{array} \quad x \quad \begin{array}{c}\textbf{Perf.}\text{ Obj.}\\\text{Patrol}\\\text{Interval}\\\textbf{(5.1.4.4)}\end{array}}$$

5.1.5 Total number of officers required per day to meet patrol interval performance objective within the **APA,** add: (5.1.2.5) + (5.1.3.5) + (5.1.4.5) .

| 7.88 |

(5.1.5)

OPTION: Complete Section **5.2** or the Supplemental Worksheet in Appendix A or **complete Sections 5.3** and **5.4.**

5.2 Uncommitted Patrol Availability – Immediate Response

5.2.1 Number of effective shifts per day

5.2.1.1 Shift length (hours),
use **(1.2.1)** . . . .

| 8.0 |
(5.2.1.1)

5.2.1.2 Calculate the effective
number of shifts per
day based on the formula
below . . . .

| 3.0 |
(5.2.1.2)

$$\begin{matrix} \text{Effective Number} \\ \text{of Shifts Per Day} \\ \textbf{(5.2.1.2)} \end{matrix} = \frac{24}{\begin{matrix}\text{Shift Length (hours)}\\ \textbf{(5.2.1.1)}\end{matrix}}$$

5.2.2 Adjusted average number of on-duty officers for
reactive activities per shift per **day**

5.2.2.1 Average daily number
of on-duty officers (NJ
for reactive activities,
use **(3.3.3)** . . . .

| 13.56 | (NJ
(5.2.2.1)

5.2.2.2 Average daily number
of on-duty officers **(N$_{rs}$)**
per shift for reactive
activities, divide:
(5.2.2.1) ÷ (5.2.1.2) . . .

| 4.52 | **(N$_{rs}$)**
(5.2.2.2)

5.2.2.3 Fraction of **non-preempt-**
able other **CFS,** divide:
(1.3.6) ÷ 100 . . . .

| 0.20 |
(5.2.2.3)

5.2.2.4 Number of non-preemptable
other **CFS,** multiply:
(5.2.2.3) x (1.3.4) . . . .

9,056.8

(5.2.2.4)

5.2.2.5 Calculate the fraction
of non-preemptable
reactive activities **(f_{npr}),**
use the formula below . . .

0.24

(f_{npr})

(5.2.2.5)

$$
\begin{array}{c}
\text{Fraction of} \\
\text{Non-Preemptable} \\
\text{Reactive} \\
\text{Activities} \\
\textbf{(f}_{npr}\textbf{)} \textbf{(5.2.2.5)}
\end{array}
=
\dfrac{
\begin{array}{c}\text{Number of} \\ \text{Accidents} \\ \textbf{(1.3.2)}\end{array}
+
\begin{array}{c}\text{Number of} \\ \text{Non-Preemptable} \\ \text{Other } \textbf{CFS} \\ \textbf{(5.2.2.4)}\end{array}
}{
\begin{array}{c}\text{Number of} \\ \text{Accidents} \\ \textbf{(1.3.2)}\end{array}
+
\begin{array}{c}\text{Number of} \\ \text{Other } \textbf{CFS} \\ \textbf{(1.3.4)}\end{array}
}
$$

5.2.2.6 Fraction of non-preemptable
administrative act. **(f_{npa}),**
divide: **(1.3.7) ÷ 100** . . .

0.12

(f_{npa})

(5.2.2.6)

5.2.2.7 Fraction of non-preemptable
self-initiated/COP
activities **(f_{nps}),** divide:
(1.3.8) ÷ 100 . . . .

0.20

(f_{nps})

(5.2.2.7)

5.2.2.8 Administrative time —
minutes per hour per
officer **(m_a),** use **(2.3)** . .

12.0

(m_a)

(5.2.2.8)

5.2.2.9 Self-initiated/COP time —
minutes per hour per
officer **(m_s),** use **(4.6)** . .

11.40

(m_s)

(5.2.2.9)

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5.2.2.10 Calculate **K₍ₐ₎,** use the
formula below . . . . .

| 0.33 | (**Kₐ**)

(5.2.2.10)

$$
\begin{array}{c}
\mathbf{K_a} \ = \\
\mathbf{(5.2.2.10)}
\end{array}
\quad
\frac{
\begin{array}{c}
\text{Administrative Activities,} \\
\text{Minutes per Hour Per Officer} \\
\mathbf{m_a\ (5.2.2.8)}
\end{array}
}{
60 \ - \
\begin{array}{c}
\text{Admin.} \\
\text{Minutes} \\
\text{Per Hour} \\
\text{Per Off.,} \\
\mathbf{m_a\ (5.2.2.8)}
\end{array}
\ - \
\begin{array}{c}
\text{S.I./COP} \\
\text{Minutes} \\
\text{Per Hour} \\
\text{Per Off.,} \\
\mathbf{m_s\ (5.2.2.9)}
\end{array}
}
$$

5.2.2.11 Calculate **Kₛ,** use the
formula below . . . . .

| 0.31 | (**Kₛ**)

(5.2.2.11)

$$
\begin{array}{c}
\mathbf{K_s} \ = \\
\mathbf{(5.2.2.11)}
\end{array}
\quad
\frac{
\begin{array}{c}
\text{Self-Initiated Activities,} \\
\text{Minutes per Hour Per Officer} \\
\mathbf{m_s\ (5.2.2.9)}
\end{array}
}{
60 \ - \
\begin{array}{c}
\text{Admin.} \\
\text{Minutes} \\
\text{Per Hour} \\
\text{Per Off.,} \\
\mathbf{m_a\ (5.2.2.8)}
\end{array}
\ - \
\begin{array}{c}
\text{S.I./COP} \\
\text{Minutes} \\
\text{Per Hour} \\
\text{Per Off.,} \\
\mathbf{m_s\ (5.2.2.9)}
\end{array}
}
$$

5.2.2.12 Calculate **Kₛₐ,** add:
(5.2.2.10) + (5.2.2.11) .

| 0.64 | (**Kₛₐ**)

(5.2.2.12)

5.2.2.13 Calculate K_{na}, multiply: (5.2.2.6) . (5.2.2.10) . .

| 0.04 | (K_{na}) |
(5.2.2.13)

5.2.2.14 Calculate K_{ns}, multiply: (5.2.2.7) x (5.2.2.11) . .

| (K_{ns}) 0.06 |
(5.2.2.14)

5.2.2.15 Calculate K_{nsa}, add: (5.2.2.13) . (5.2.2.14) .

| 0.10 | (K_{nsa}) |
(5.2.2.15)

5.2.2.16 Calculate the **adjusted** average number of officers (N_{ars}) required for reactive activities per shift per **day,** use the formula below . . . .

| 1.39 | (N_{ars}) |
(5.2.2.16)

$$\begin{array}{l}\text{Adjusted Average}\\\text{Number of Officers}\\\text{for Reactive Act.}\\\text{Per Shift Per Day}\\(N_{ars})\ (5.2.2.16)\end{array} = \frac{\begin{array}{c}\text{No. Of}\\\text{Officers,}\\\text{Reactive Act.}\\\text{per Shift}\ (N_{rs})\ \ \text{x}\ \ (f_{npr}\ +\ K_{nsa})\\(5.2.2.2)\qquad\quad(5.2.2.5)\ (5.2.2.15)\end{array}}{1\ +\ \begin{array}{c}K_{nsa}\\(5.2.2.15)\end{array}}$$

5.2.3 Select table in Appendix A based on K_{nsa} (5.2.2.15) from from the chart below . . . . . .

| Table A-2 |
(5.2.3)

If K_{nsa} (5.2.2.15) is in the range	Use Table (5.2.3)
0.0 - .099	A-1
0.1 - .199	A-2
0.2 - .299	A-3
0.3 - .399	A-4
0.4 - .499	A-5
0.5 - .599	A-6
0.6 - .699	A-7
0.7 - .799	A-8
0.8 - .899	A-9
0.9 - .999	A-10
1.0 - 1.099	A-11
1.1 - 1.199	A-12
1.2 - 1.299	A-13

5.2.4 Total number of additional officers required for patrol per shift to provide immediate response for the performance objective percentage of emergency accidents and other **CFS**

5.2.4.1 Performance objective **(IR%)**, percentage of emergency accidents and other **CFS** activities, immediate response (a number between **50** and **99**) . . . .

| 80.0 | (IR%) |

(5.2.4.1)

5.2.4.2 Total number of on-duty officers officers **($N_{ir\%s}$)** required per shift to meet the immediate response performance objective, use **N_{ars} (5.2.2.16)**, the table selected for **(5.2.3)**, and **(IR%) (5.2.4.1)** . . . .

| 1.90 | ($N_{ir\%s}$) |

(5.2.4.2)

5.2.4.3 Calculate K_{dsa}, subtract:
(5.2.2.12) − (5.2.2.15) . .

| 0.54 | (K_{dsa})
(5.2.4.3)

5.2.4.4 Calculate the <u>additional</u>
number of officers per shift
needed per day to meet
the immediate response
performance objective **(IR%)**,
use the formula below . . .

| −2.59 |
(5.2.4.4)

$$
\begin{array}{l}
\underline{\text{Additional}} \text{ No. Of} \\
\text{Officers Needed} \\
\text{Per Shift For} \\
\text{Immediate } \textbf{Resp.} \\
\text{(5.2.4.4)}
\end{array}
\;=\;
\dfrac{
\underset{(5.2.4.2)}{N_{ir\%s}}
\;-\;
\underset{(5.2.2.2)}{N_{rs}}
\;\times\;
\underset{(5.2.2.5)}{(1 \;-\; f_{npr}}
\;+\;
\underset{(5.2.4.3)}{K_{das})}
}{
1 \;+\; \underset{(5.2.4.3)}{K_{dsa}}
}
$$

5.2.4.5 Determine the actual <u>additional</u>
number of officers per shift
(N_{airs}) needed per day to
meet the immediate response
performance objective **(IR%)**,
select the larger of zero
and **(5.2.4.4)** . . . .

| 0.0 | (N_{airs})
(5.2.4.5)

5.2.4.6 Number of additional
on-duty officers **(N_{air})**
required per day to meet
the immediate response
performance objective
(IR%), multiply:
(5.2.4.5) x (5.2.1.2);
or enter value from
Step **(A.8)** . . . .

| 0.0 | (N_{air})
(5.2.4.6)

Continue with Section **5.5.**

OR

5.3 Uncommitted Patrol Availability — Travel **Time for Emergency Activities**

    5.3.1 Average number of on-duty officers for reactive activities per shift per day

        5.3.1.1 Shift length (hours), use **(1.2.1)** . . . .

8.0

(5.3.1.1)

        5.3.1.2 Calculate the effective number of shifts per day based on the formula below . . . .

3.0

(5.3.1.2)

$$\begin{matrix} \text{Effective Number} \\ \text{of Shifts Per Day} \\ \textbf{(5.3.1.2)} \end{matrix} = \frac{24}{\begin{matrix}\text{Shift Length (hours)}\\ \textbf{(5.3.1.1)}\end{matrix}}$$

        5.3.1.3 Average daily number of on-duty officers (N_r) for reactive activities, use **(3.3.3)** . . . .

13.56

(N_r)

(5.3.1.3)

        5.3.1.4 Average daily number of on-duty officers (N_{rs})

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per shift for reactive
activities, divide:
(5.3.1.3) ÷ (5.3.1.2) . . .

| 4.52 | (**N**$_{rs}$)

(5.3.1.4)

5.3.2 Maximum number of uncommitted patrol units
for response to emergency activities

5.3.2.1 Area (square miles) of
APA . . . . • . . . . .

| 36.0 |

(5.3.2.1)

5.3.2.2 Average response speed
(MPH) for emergency
activities . . . .

| 38.0 |

(5.3.2.2)

5.3.2.3 Avg. travel time (emergency
activities) performance
objective (minutes) . . . .

| 4.50 |

(5.3.2.3)

5.3.2.4 <u>Maximum</u> number of additional officers
required per shift within the **APA** to meet
the average travel time performance
objective for emergency activities

5.3.2.4.1 Calculate **K**$_{tt}$**,** use
the formula below .

| 0.234 | (**K**$_{tt}$)

(5.3.2.4.1)

$$K_{tt} = \frac{40}{\text{Response Speed (MPH)} \quad \textbf{x} \quad \text{Travel Time \textbf{(min)}}}$$
$$\text{(5.3.2.2)} \qquad \text{(5.3.2.3)}$$

5.3.2.4.2 Calculate K_{tt}^2,
multiply:
(5.3.2.4.1) **x**
(5.3.2.4.1) . . . .

0.055	(K_{tt}^2)

(5.3.2.4.2)

5.3.2.4.3 <u>Maximum</u> number of
officers (N_{maxtt})
required per shift
for rapid response
to emergency act.,
use the formula
below . . . .

1.97	(N_{maxtt})

(5.3.2.4.3)

<u>Maximum</u> Daily
No. of On-Duty
Officers (N_{maxtt}),
Rapid Response to $=$ K_{tt}^2 **x**   Area
Emerg. Activities   (5.3.2.4.2)   (5.3.2.1)
(5.3.2.4.3)

5.3.3 <u>Adjusted</u> number of additional officers
required within the **APA** to meet the
average travel time performance objective
for emergency activities

5.3.3.1 Fraction of non-preemptable
other **CFS,** divide:
(1.3.6) ÷ 100 . . . .

0.20

(5.3.3.1)

5.3.3.2 Number of non-preemptable
other **CFS,** multiply:
(5.3.3.1) **x** **(1.3.4)** . . . .

9,056.8

(5.3.3.2)

5.3.3.3 Calculate the fraction
of non-preemptable
reactive activities **(f_{npr})**,
use the formula below . . .

$$\boxed{0.24} \quad \textbf{(f}_{npr}\textbf{)}$$

(5.3.3.3)

Fraction of
Non-Preemptable
Reactive
Activities
(f_{npr}) (5.3.3.3) $=$

$$\frac{\text{Number of Accidents } (1.3.2) \; + \; \text{Number of Non-Preemptable Other } \textbf{CFS} \; (5.3.3.2)}{\text{Number of Accidents } (1.3.2) \; + \; \text{Number of Other } \textbf{CFS} \; (1.3.4)}$$

5.3.3.4 Fraction of non-preemptable
administrative activities
divide: **(1.3.7) ÷ 100** . . ..

$$\boxed{0.12} \quad \textbf{(f}_{npa}\textbf{)}$$

(5.3.3.4)

5.3.3.5 Fraction of non-preemptable
self-initiated/COP act.,
divide: **(1.3.8) ÷ 100** . . .

$$\boxed{0.20} \quad \textbf{(f}_{nps}\textbf{)}$$

(5.3.3.5)

5.3.3.6 Administrative time –
minutes per hour per
officer **(m_a)**, use **(2.3)** . .

$$\boxed{12.00} \quad \textbf{(m}_a\textbf{)}$$

(5.3.3.6)

5.3.3.7 Self-initiated/COP time –
minutes per hour per
officer **(m_s)**, use **(4.6)** . .

$$\boxed{11.40} \quad \textbf{(m}_s\textbf{)}$$

(5.3.3.7)

5.3.3.8 Calculate **K_a**, use the
formula below . . . .

$$\boxed{0.33} \quad \textbf{(K}_a\textbf{)}$$

(5.3.3.8)

$$K_a =$$
(5.3.3.8)

Administrative Activities,
Minutes per Hour Per Officer
m_a **(5.3.3.6)**

		Admin. Minutes	S.I./COP Minutes
60	−	Per Hour Per **Off.**, m_a **(5.3.3.6)**	Per Hour Per Off., m_s **(5.3.3.7)**

5.3.3.9 Calculate K_s, use the
formula below . . . .

0.31	**(K_s)**

(5.3.3.9)

$$K_s =$$
(5.3.3.9)

Self-Initiated Activities,
Minutes per Hour Per Officer
m_s **(5.3.3.7)**

		Admin. Minutes	S.I./COP Minutes
60	−	Per Hour Per Off., m_a **(5.3.3.6)**	Per Hour Per Off., m_s **(5.3.3.7)**

5.3.3.10 Calculate K_{sa}, add:
(5.3.3.8)   **(5.3.3.9)** . .

0.64	**(K_{sa})**

(5.3.3.10)

5.3.3.11 Calculate K_{na}, multiply:
(5.3.3.4) x **(5.3.3.8)** . .

0.04	**(K_{na})**

(5.3.3.11)

5.3.3.12 Calculate K_{ns}, multiply:
(5.3.3.5) x **(5.3.3.9)** . .

0.06	**(K_{ns})**

(5.3.3.12)

5.3.3.13 Calculate K_{nsa}, add: $\boxed{\textbf{0.10}}$ (K_{nsa})
(5.3.3.11) + (5.3.3.12) .

(5.3.3.13)

5.3.3.14 Calculate K_{dsa}, subtract: $\boxed{\blacksquare\textbf{0.54}\blacksquare}$ (K_{dsa})
(5.3.3.10) - (5.3.3.13) .

(5.3.3.14)

5.3.3.15 Calculate the <u>adjusted</u>
number of additional
officers required per shift
to meet the average travel
time performance
objective, use the $\boxed{\textbf{-2.55}}$
formula below . . . . . .

(5.3.3.15)

$$
\begin{array}{l}
\underline{\textbf{Adjusted}} \\
\text{Daily No. of} \\
\text{Additional} \\
\text{Officers} \\
\textbf{(5.3.3.15)}
\end{array}
=
\dfrac{
\begin{array}{c}
N_{maxtt} \quad - \quad N_{rs} \quad \textbf{X} \quad (\ 1 \quad - \quad f_{npr} \ + \ K_{dsa} \ ) \\
\text{(5.3.2.4.3)} \quad \text{(5.3.1.4)} \qquad \qquad \text{(5.3.3.3)} \ \text{(5.3.3.14)}
\end{array}
}{
\begin{array}{c}
1 \quad + \quad K_{dsa} \\
\qquad \qquad \text{(5.3.3.14)}
\end{array}
}
$$

5.3.4 <u>Actual</u> number of additional officers
required per shift to meet the
travel time performance objective for
emergency activities, select
the <u>larger</u> of zero **(0)** and $\boxed{\textbf{0.0}}$
and **(5.3.3.15)** . . . .

(5.3.4)

5.3.5 <u>Actual</u> number of additional officers
(N_{ett}) required per day to meet the
travel time performance objective
for emergency activities, multiply:
(5.3.1.2) x (5.3.4) . . . .

0.00	**(N_{ett})**

(5.3.5)

5.4 Uncommitted Patrol Availability - Travel Time
for Non-Emergency Activities

5.4.1 Shift length (hours),
use **(1.2.1)** . . . .

8.0

(5.4.1)

5.4.2 Area (square miles) of the
APA . . . .

36.0

(5.4.2)

5.4.3 Average response speed
(MPH) for non-emergency
reactive activities ... .

20.0

(5.4.3)

5.4.4 Average travel time **(non-**
emergency activities) performance
objective (minutes) . . ..

30.0

(5.4.4)

5.4.5 Number of officers required
within the **APA** to meet the
average travel time
performance objective for
non-emergency activities

5.4.5.1 Calculate **K_{tt},** use the
formula below . . . .

0.067	**(K_{tt})**

(5.4.5.1)

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$$K_{tt} = \frac{40}{\begin{array}{cc} \text{Response} & \text{Travel} \\ \text{Speed (MPH)} \ \mathbf{x} & \text{Time (min)} \\ \mathbf{(5.4.3)} & \mathbf{(5.4.4)} \end{array}}$$

5.4.5.2 ((5.4.5.1) K_{tt}² (5.4.5.1)ly· . .

| 0.004 | $(K_{tt}{}^2)$ |

(5.4.5.2)

5.4.5.3 Number of officers (N_{nett}) required per day for rapid response to non-emergency activities, use the formula below ...

| (N_{nett}) 0.48 |

(5.4.5.3)

$$\begin{array}{c} \text{Daily} \\ \textbf{No.}\text{of On-Duty} \\ \text{Officers } (\mathbf{N_{att}}) \\ \text{For Rapid Response} \\ \textbf{(Non-Emerg. Act.)} \\ \mathbf{(5.4.5.3)} \end{array} = \frac{24 \quad \mathbf{x} \quad K_{tt}{}^2 \quad \mathbf{x} \quad \text{Area}}{\begin{array}{c} (5.4.5.2) \quad\quad (5.4.2) \\ \hline \text{Shift Length (hours)} \\ \mathbf{(5.4.1)} \end{array}}$$

5.5 Uncommitted Patrol Availability – Travel Time

Number of officers $(\mathbf{N_{tt}})$ required to meet the travel time performance objectives for both emergency and non-emergency activities, select the <u>larger</u> of **(5.3.5)** and **(5.4.5.3)** ...

| 0.48 | $(\mathbf{N_{tt}})$ |

(5.5)

5.6 Uncommitted Patrol Availability

Total officers required within
the **APA,** select either **(5.2.4.6)**
or (5.5) . . . .

0.48

(5.6)

5.7 Total Number of Officers Required for Uncommitted Patrol

Average number of officers (N_p)
required per day for uncommitted
patrol within the ABA, select the
larger of (5.1.5) and **(5.6)** . . . .

7.88
(N_p)

(5.7)

WORKSHEET **6:** Average **Daily** Number of **On-Duty Officers**

Objective: Determine the average total number of officers
required per day within the **APA.**

Method: Combine the total number of officers required for
reactive **(N$_r$)** and patrol activities **(N$_p$)** with the
per officer time requirements for self-init-
iated/COP **(m$_s$)** and administrative **(m$_a$)** activities.
Adjust the required number of officers based on
the percentage of two-officer patrols and, if
applicable, minimum daily patrol staffing levels,

6.1 Number of On-Duty Officers per Day - All One-Officer Patrols

6.1.1 Administrative time - minutes
per hour per officer,
use **(2.3)** . . . .

12.00

(m$_a$)

(6.1.1)

6.1.2 Average number of officers
required per day to meet
reactive time workload,
use **(3.3.3)** . . . .

13.56

(N$_r$)

(6.1.2)

6.1.3 Self-initiated/COP time -
minutes per hour per officer,
use **(4.6)** . . . .

11.40

(m$_s$)

(6.1.3)

6.1.4 Average number of officers
required per day to meet patrol
time requirements, use **(5.7)** ...

7.88

(N$_p$)

(6.1.4)

6.1.5 Average total number of on-duty officers required per day for all patrol activities within the **APA,** one officer per unit, use the formula below . . . .

$$\boxed{\textbf{35.16}}$$

(6.1.5)

Average Total Number
of On-Duty Officers $=$ $\dfrac{N_r\ (6.1.2) \quad + \quad N_p\ (6.1.4)}{1 - \dfrac{m_a\ (6.1.1)}{60} - \dfrac{m_s\ (6.1.3)}{60}}$
Per Day **(6.1.5)**

6.2 Adjustment for **Two-Officer** Patrols

<u>Note</u> : If two-officer patrols are not used, enter **(6.1.5)** in **(6.2.4)** and continue with Section **6.3.**

6.2.1 Percentage of time patrol units within the **APA** are staffed with two officers . . ..

$$\boxed{\textbf{0.0}}$$

(6.2.1)

6.2.2 Fraction of time patrol units within the **APA** are staffed with two officers, divide: **(6.2.1)** ÷ **100** . . . . . .

$$\boxed{\textbf{0.0}}$$

(6.2.2)

6.2.3 Adjustment factor: average number of officers per unit, add: 1 + **(6.2.2)** . . . .

$$\boxed{\textbf{1.00}}$$

(6.2.3)

6.2.4 Average total number of on-duty
officers required per day for all
patrol activities, multiply:
(6.1.5) x (6.2.3) . . . .

35.16

(6.2.4)

6.3 Adjustment for Minimum Patrol Staffing Levels

<u>Note</u> **:** If minimum patrol staffing levels are not used, enter
(6.2.4) into **(6.3.2)** and continue with Worksheet **7.**

6.3.1 Average minimum number of on-duty
officers required per day for all
patrol activities, based on
agency policy . . . .

(N_{min}) **15.0**

(6.3.1)

6.3.2 Average daily number of on-duty
officers required for all patrol
activities (N_0), select the
<u>larger</u> of **(6.2.4)** and **(6.3.1)** ..

(**35.16**

J

(6.3.2)

WORKSHEET **7:** <u>Special Assignments and Field Supervision</u>

> Objective: Determine **(1)** the revised number of on-duty offic-
> ers required per day for officers on special as-
> signments and **(2)** the number of field supervisors
> required.

> Method: The number of officers for special assignments is
> based on the number of specialists assigned by the
> agency and the percentage of time each spends on
> field patrol activities. The number of field
> supervisors is based on the span of supervision
> (set by agency policy) and the percentage of field
> supervisor on-duty time spent on patrol activities.

7.1 Number of Full-Time, On-Duty Officers Required per Day,
Adjusted for Field Supervisors

> **7.1.1** Average number of officers to
> be supervised by each field
> supervisor, use **(1.2.3)** . . . . . .
>
> | **6.0** |
> |:---:|
> (7.1.1)

> **7.1.2** Percentage of field supervisor
> on-duty time spent on patrol
> activities (a number between 0
> and **100)**, use **(1.2.4)** . . . . . .
>
> | **25.0** |
> |:---:|
> (7.1.2)

> **7.1.3** Fraction of field supervisor
> on-duty time spent on patrol
> activities, divide:
> **(7.1.2)** ÷ 100 . . . .
>
> | **0.25** |
> |:---:|
> (7.1.3)

> **7.1.4** Total number of on-duty officers
> required per day within the
> **APA (N_0)** for all patrol
> activities, use **(6.3.2)** . . . . .
>
> | **35.16** | (NJ
> |:---:|
> (7.1.4)

7.1.5 Adjustment factor **(K$_f$)**,
   use formula below . . . .

| **0.96** | **(K$_f$)** |

(7.1.5)

$$\text{Adjustment Factor } (K_f) \text{ (7.1.5)} = \frac{\text{Officers Per Field Sup. (7.1.1)}}{\text{Officers Per Field Sup. (7.1.1)} + \text{Fraction of Field Sup. Time on Patrol (7.1.3)}}$$

7.1.6 Adjusted daily number of
   full-time, on-duty officers
   (N$_{ao}$) required per
   day, use formula below . . . . .

| **33.75** | **(N$_{ao}$)** |

(7.1.6)

$$\text{Adjusted Number of Full-Time, On-Duty Officers Per Day } (N_{ao}) \text{ (7.1.6)} = K_f \times \text{No. of On-Duty Officers Per Day } (N_o) \text{ (7.1.4)}$$

NOTE: If no special assignment personnel are to be included, enter
(7.1.6) into **(7.2.4)** and continue with Section **7.3.** If
special assignment personnel are to be included, continue
with Section **7.2.**

7.2 Number of On-Duty Officers Required Per Day, Adjusted for **Special** Assignment Personnel

    7.2.1 Special Assignment 1

        7.2.1.1 Assign, 1 name . | Traffic **Enf.** — Radar |

                                               (7.2.1.1)

        7.2.1.2 Average number of **on-duty** officers per day on specialized assignment 1 . . . . | 3.0 | (N_{s1})

                                               (7.2.1.2)

        7.2.1.3 Percentage of on-duty time spent on patrol activities by officers assigned to special assignment 1 (a number between 0 and **100)** . . . . | 50.0 |

                                               (7.2.1.3)

        7.2.1.4 Percentage of on-duty time spent on non-patrol activities by officers assigned to special assignment **1,** subtract: **100 — (7.2.1.3)** . . . . . | 50.0 |

                                               (7.2.1.4)

        7.2.1.5 Fraction of on-duty time spent on non-patrol activities by officers assigned to special assignment **1,** divide: **(7.2.1.4)** ÷ 100 . . . . . | (f_{s1}) 0.50 |

                                               (7.2.1.5)

7.2.1.6 Adjusted daily number
of on-duty officers
assigned to special
assignment **1,** use
formula below . . . . . .

| **1.44** | **(N_{as1})** |

(7.2.1.6)

| Adjusted Number On-Duty Officers, Special Assignment **1 (N_{as1}) (7.2.1.6)** | **=** | Number On-Duty Officers S.A. 1 **(N_{s1}) (7.2.1.2)** | **x** | Fraction Time On Non-Patrol Activities **(f_{s1}) (7.2.1.5)** | **x** | Adjustment Factor **(K_f)** **(7.1.5)** |

NOTE: If personnel for a second special assignment are to be
included, complete steps **(7.2.2.1)** through **(7.2.2.6).** If
not, enter zeros for steps **(7.2.2.6)** and **(7.2.3.6)** and
continue with Step **7.2.4.**

7.2.2 Special Assignment 2

7.2.2.1 Assign. 2 name .

| Crime Prevention |

(7.2.1.1)

7.2.2.2 Average number of
<u>on-duty</u> officers per
day on specialized
assignment 2 . . . . . .

| **2.0** | **(N_{s2})** |

(7.2.2.2)

7.2.2.3 Percentage of on-duty
time spent on patrol
activities by officers
assigned to special
assignment 2 (a number
between 0 and **100)** . . . .

| **30.0** |

(7.2.2.3)

7.2.2.4 Percentage of on-duty time spent on non-patrol activities by officers assigned to special assignment **2,** subtract: **100 - (7.2.2.3)** . . . . .

70.0

(7.2.2.4)

7.2.2.5 Fraction of on-duty time spent on non-patrol activities by officers assigned to special assignment **2,** divide: **(7.2.2.4) ÷ 100** . . . . .

0.70

(f_{s2})

(7.2.2.5)

7.2.2.6 Adjusted daily number of on-duty officers assigned to special assignment **2,** use formula below . . . . .

1.34

(N_{as2})

(7.2.2.6)

Adjusted Number On-Duty Officers, Special Assignment 2 (N_{as2}) (7.2.2.6)	=	Number On-Duty Officers S.A. 2 (N_{s2}) (7.2.2.2)	x	Fraction Time On Non-Patrol Activities (f_{s2}) (7.2.2.5)	x	Adjustment Factor (K_f) (7.1.5)

NOTE: If personnel for a third special assignment are to be included, complete steps **(7.2.3.1)** through **(7.2.3.6).** If not, enter zero for step **(7.2.3.6)** and continue with Step **7.2.4.**

7.2.3 Special Assignment 3

7.2.3.1 Assign. 3 name .

(7.2.3.1)

7.2.3.2 Average number of **on-duty** officers per day on specialized assignment 3 . . . .

$(\mathbf{N}_{s3})$ ---

(7.2.3.2)

7.2.3.3 Percentage of on-duty time spent on patrol activities by officers assigned to special assignment 3 (a number between 0 and **100)** . . . .

(7.2.3.3)

7.2.3.4 Percentage of on-duty time spent on non-patrol activities by officers assigned to special assignment **3,** subtract: **100 — (7.2.3.3)** . . . . .

(7.2.3.4)

7.2.3.5 Fraction of on-duty time spent on non-patrol activities by officers assigned to special assignment **3,** divide: **(7.2.3.4) ÷ 100** . . . . .

$(\mathbf{f}_{s3})$ ---

(7.2.3.5)

7.2.3.6 Adjusted daily number of on-duty officers assigned to special assignment **3,** use formula below . . . . . .

$(\mathbf{N}_{as3})$

(7.2.3.6)

Adjusted Number On-Duty Officers, Special Assignment 3 (N_{as3}) (7.2.3.6)	=	Number On-Duty Officers S.A. 3 (N_{s3}) (7.2.3.2)	x	Fraction Time On Non-Patrol Activities (f_{s3}) (7.2.3.5)	x	Adjustment Factor (K_f) (7.1.5)

7.2.4 Adjusted total daily number of on-duty officers required per day, use formula below ... ..

$\boxed{36.53}$ (N_{ot})

(7.2.4)

$$\begin{array}{l} \text{Adjusted Total} \\ \text{Number of On-Duty} \\ \text{Officers Per} \\ \quad \textbf{Day } (N_{ot}) \\ \quad \textbf{(7.2.4)} \end{array} = \begin{array}{c} N_{ao} \\ (7.1.6) \end{array} + \begin{array}{c} N_{as1} \\ (7.2.1.6) \end{array} + \begin{array}{c} N_{as2} \\ (7.2.2.6) \end{array} + \begin{array}{c} N_{as3} \\ (7.2.3.6) \end{array}$$

7.3 Total Number of On-Duty Field Supervisors Required Per Day for the Adjusted Number of On-Duty Officers

7.3.1 Total number of on-duty field supervisors (N_{os}) required per day, day, divide: (7.2.4) ÷ (7.1.1)..

$\boxed{6.09}$ (N_{os})

(7.3.1)

WORKSHEET **8:** <u>Total Staff Patrol Requirements</u>

<u>Objective</u>: Determine total patrol staff needed to support the required daily on-duty field personnel,

<u>Method</u>: Use the shift relief factor, daily on-duty patrol staffing requirements, and the number of command positions based on agency policy.

8.1 On-Duty Officers and Field Supervisors Required per Day

> **8.1.1** Total number of on-duty officers per day within the **APA,** use **(7.2.4)** . . . .
>
> | 36.53 | (N_{ot}) |
> (8.1.1)

> **8.1.2** Total number of on-duty field supervisors per day within the **APA,** use **(7.3.1)** . . . .
>
> | 6.09 | (N_{os}) |
> (8.1.2)

8.2 Shift Relief Factor

> **8.2.1** Shift **(1.2.1)**h (.hours), ...
>
> | 8.0 |
> (8.2.1)

> **8.2.2** Total hours on one shift during one year, multiply: 365 **x (8.2.1)** . . . .
>
> | 2,920.0 | (H_t) |
> (8.2.2)

8.2.3 Average work week (average
number of paid hours per week
per officer), use **(1.2.2.1)**. . .

| **40.0** | (**AWW**) |

(8.2.3)

8.2.4 Average number of paid hours
of work per year per officer,
use formula below . . . .

| **2,085.71** | (**H$_y$**) |

(8.2.4)

Average Number of Paid
Hours of Work per Year $=$ $\dfrac{365 \quad \mathbf{X} \quad \text{AWW (8.2.3)}}{7}$
per Officer (**H$_y$**)

8.2.5 Average number of benefit
(paid) hours off per year
per officer, use **(1.2.2.2)** . . . .

| **275.2** | (**H$_b$**) |

(8.2.5)

8.2.6 Average number of on-duty
hours on temporary assignments
(non-patrol) per officer
per year, use **(1.2.2.3)** . . . . .

| **138.7** | (**H$_{ta}$**) |

(8.2.6)

8.2.7 Average number of on-duty,
hours on patrol per year per
officer, use formula below . . . .

| **1,671.81** | (**H$_p$**) |

(8.2.7)

Average Number of
On-Duty Hours On $=$ $\underset{(8.2.4)}{H_y}$ $-$ $\underset{(8.2.5)}{H_b}$ $-$ $\underset{(8.2.6)}{H_{ta}}$
Patrol per Year per
Officer (**H$_p$**)

8.2.8 Shift relief factor
divide: **(8.2.2)** $\div$ **(8.2.7)** . . . .

| **1.747** | (**SRF**) |

(8.2.8)

8.3 Total **Number** of **Required** Officers and Field
Supervisors Within **the APA**

8.3.1 Total number of patrol officers,
multiply: **(8.1.1) x (8.2.8)** . . .

| 63.81 | (N_t) |

(8.3.1)

8.3.2 Total number of field
supervisors, multiply:
(8.1.2) x (8.2.8) . . . .

| 10.63 | (N_s) |

(8.3.2)

8.3.3 Total number of officers and
field supervisors, add:
(8.3.1) + (8.3.2) . . . .

| 74.44 |

(8.3.3)

8.4 Number of Command Personnel - Agency Policy

Enter the number of command staff **(N_c)**
required for the number of officers
and field supervisors in **(8.3.3)** . . . .

| 6.0 | (N_c) |

(8.4)

8.5 Total Patrol Staff Requirement for the **APA**

8.5.1 Number of officers within
the **APA,** use **(8.3.1)** . . . .

| (N_t) 63.81 |

(8.5.1)

8.5.2 Number of field supervisors
within the **APA,** use **(8.3.2)** . . .

| **10.63** | (NJ

(8.5.2)

8.5.3 Number of command personal
within the **APA,** use **(8.4)** . . . . .

| **6.0** | (NJ

(8.5.3)

8.5.4 Total required patrol
staff for the **APA,** add:
(8.5.1) = **(8.5.2)** = **(8.5.3)** . . . . .

| **80.44** | $(\mathbf{N_{tot}})$

(8.5.4)

WORKSHEET **9**:   <u>Allocation of Patrol **Personnel Among** Several **APAs**</u>

<u>Objective</u>: Determine the appropriate number of personnel to be assigned to each **APA** based on the estimated PAM staffing levels for each **APA.**

<u>Method</u>: Based on the number of personnel estimated for each **APA,** two reallocations of current and new personnel are determined,   The unconstrained allocation redistributes all personnel, both current and new, among the **APAs** in the same proportion as the PAM estimates. The constrained allocation restricts the allocation to only new (or reduced) personnel insuring that no **APA** loses staffing when new personnel are added (or that no **APA** gains staffing when personnel reductions are applied).

See Chapter 4 in the <u>Manual</u> for the instructions for Worksheet **9.**

<u>Table 4 - 1</u>

Worksheet for the Allocation of Patrol Personnel
Among Three Shifts Based on PAM Staff Estimates

Total Number of Additional (or Reduced) Personnel $\boxed{6}$ **(TA)**
for All Shifts **(9.1.1)** . . . .

Shift	Current Staff (9.1.3) Col. 1	PAM Staff Est. (9.1.5) Col. 2	Unconst Reallo. (9.1.7) Col. 3	Diff. Col. 1 -Col. 3 (9.2.1) Col. 4	(9.2.3.1) or (9.2.4.1 Col. 5	To Be Added (9.2.3.3) or Reduced (9.2.4.3) Col. 6	Rounded (9.2.6) Col. 7	Constr. Reallo. Col. 1 +Col. 7 (9.2.8) Col. 8
1	**24**	**23.80**	**23.0**	**1.0**	**0.0**	**0.0**	0	**24**
2	**24**	**29.30**	**28.4**	**-4.4**	**-4.4**	**3.8**	4	**28**
3	**24**	**27.44**	**26.6**	**-2.6**	**-2.6**	**2.2**	2	**26**
4								
5								
6								
Col. Sum	**72** (9.1.4) **(TC)**	**80.54** (9.1.6) **(TE)**	**78.0** (9.1.8)	**-6.0** (9.2.2)	**-7.0** (9.2.3.2) or (9.2.4.2) **(TN)**	**6.0** (9.2.5)	**6** (9.2.7)	**78** (9.2.9)
Sum Check	**72** (9.1.2) **(TC)**		**78.0** (9.1.1) + (9.1.2) **(TA+TC)**	**-6.0** -1 x (9.1.1) **(-TA)**		**6.0** (9.1.1) **(TA)**	6 (9.1.1) **(TA)**	**78** (9.1.1) + (9.1.2) **(TA+TC)**

APPENDIX **D:** <u>Derivations of the Major Formulas Used in PAM</u>

The following nine sections contain derivations of the major
formulas used in the PAM model and is intended for those users who
wish to examine more closely the relationships between the input
data and the calculated results, For some derivations, familiarity
with algebraic operations is needed to follow the discussion and
considerable use is made of notational shortcuts to reduce the
length of each **section.** Since many of the notations are not used
elsewhere in the <u>Manual</u>, definitions are supplied in each section
as new terminology and variables are introduced,   All page,
section, and step numbers identified in the derivations refer to
locations in the <u>Manual</u>,

APPENDIX **D.1**:   <u>Average Number of **On-Duty** Officers **(N$_r$)** Required</u>
<u>Per **Day** Within the **APA** To Meet the **Average Daily**</u>
<u>**(Obligated** Time) Workload (Worksheet 3)</u>

The formula in Worksheet 3 that is used to determine the average number of on-duty officers required per day within the **APA** to meet the average daily obligated time workload is given by:

$$N_r \; (3.3.3) \; = \; \frac{\text{Total Average Daily Obligated Time Workload } (3.3.1)}{\text{Shift Length } (3.3.2)} \qquad (D.1.1)$$

where obligated time refers to the time required by all patrol units to respond to and service all **CFS** and accidents in the **APA**. The formula for **N$_r$** in Worksheet 3 is based on the assumption that <u>all patrol units are one-officer units only</u>.   An adjustment for two-officer units is available in Worksheet **6.**

The derivation of formula **(D.1.1)** is based on the recognition that, at a minimum, there must be sufficient reactive patrol resources to provide enough on-duty time (i.e., there must be enough patrol officers) to respond to and service all reactive (obligated time) workload; that is,

$$
\begin{array}{ccc}
\text{Total} & & \text{Total} \\
\text{Reactive Patrol} & = & \text{Reactive} \qquad\qquad (D.1.2) \\
\text{Resources} & & \text{Workload}
\end{array}
$$

The total reactive workload for any period of time (days) can be measured by determining the total obligated time **(TOT)** required for all **CFS** and accidents during the period.   The total reactive patrol resources for any period of time can be expressed in hours as:

$$
\begin{array}{ccc}
\text{Total} & & \\
\text{Reactive Patrol} & = & N_r \; \textbf{x} \; S_l \; \textbf{x} \; \textsubscript{D} \qquad\qquad (D.1.3) \\
\text{Resources} & &
\end{array}
$$

where:

N_r - the average number of on-duty officers per **day,**

S_l - shift length in hours, and

D - total number of days in the time period used to measure the total obligated time workload.

Replacing the total reactive patrol resources in **(D.1.2)** with **(D. 1.3)** and replacing the total reactive workload with total obligated time **(TOT)** yields:

$$N_r \ \times \ S_l \ \times \ D \ = \ TOT \qquad\qquad (D.1.4)$$

Solving **(D.1.4)** for N_r gives:

$$N_r \ = \ \frac{TOT}{S_l \ \times \ D} \qquad\qquad (D.1.5)$$

The expression TOT/D equals the average daily obligated time workload **(ADOT);** that is,

$$ADOT \ = \ \frac{TOT}{D} \qquad\qquad (D.1.6)$$

Replacing TOT/D with **ADOT** in **(D.1.5)** yields **(D.1.1);** that is,

$$N_r \ (3.3.3) \ = \ \frac{ADOT \ (3.3.1)}{S_l \ (3.3.2)} \qquad\qquad (D.1.7)$$

APPENDIX **D.2:** <u>Average Number of **On-Duty Officers (N$_{ppi}$)** Required Per Day To Meet the Patrol Interval Performance Requirement Objective Within the **APA** (Section **5.1)**</u>

<u>Derivation of the General Formula for Patrol Interval</u>

The patrol interval is a measure of the intensity or level of patrol coverage of a given roadway segment. Patrol interval, measured in hours, can be defined in several ways. One definition is that the patrol interval represents the average time it will take a fixed number of patrol units to drive over every roadway mile in the jurisdiction. An alternative but equivalent definition is that the patrol interval indicates the average time a stranded motorist will have to wait for an officer, <u>on uncommitted patrol,</u> to drive bye

Important assumptions associated with the patrol interval are that:

- Uncommitted patrol activity occurs randomly over all roadways of the same type; that is, all roadways within each type are treated equally, and

- Uncommitted patrol activity only occurs when a patrol unit is not occupied with administrative, reactive, or self-initiated duties.

Both assumptions are important and limiting. The assumption that all roadways are patrolled equally is usually not the case because of the greater importance of some roadways than others due to traffic volume and accident experience. Basing the patrol interval on "uncommitted" or **"free"** patrol time ignores the fact that stranded motorists may be observed and reported by units while engaged in other activities.

Calculation of the patrol interval depends on the number of roadway miles, the number of patrol units, the average patrol speed, and the amount of time spent on uncommitted patrol. The formula for determining the patrol interval is given by:

$$PI = \frac{HM}{N \times PS \times f_u} \tag{D.2.1}$$

D - 5

where:

   PI - patrol interval (hours),

   HM - total number of roadway miles,

   N - total number of patrol units on duty,

   PS - average patrol speed (MPH), and

   f_u - fraction of time spent on uncommitted time.

Formula **(D.2.1)** can be derived by using the definition that the patrol interval represents the average amount of time that it will take a fixed number of patrol units to cover the entire roadway system.   This definition can also be stated in the form of a question: If it is known how many miles all units drive collectively in one hour while on uncommitted patrol, how many hours will it take to cover the entire roadway system? The question implies that the total roadway miles **(HM)** and the average miles driven per hour **(AHM)** by all units are known and are related to the patrol interval **(PI)** as:

$$HM \quad = \quad AHM \times PI \hspace{4cm} (D.2.2)$$

Rearranging the terms in **(D.2.2)** yields:

$$PI \quad = \quad \frac{HM}{AHM} \hspace{4cm} (D.2.3)$$

The average number of roadway miles driven per hour **(AHM)** by all units can be expressed as:

$$AHM \quad = \quad AM \times N \hspace{4cm} (D.2.4)$$

where:

N – total number of units on duty, and

AM – **average** miles driven **per hour per unit.**

Replacing **AHM** in **(D.2.3)** with **(D.2.4)** yields:

$$PI = \frac{HM}{AM \times N} \tag{D.2.5}$$

The average miles driven per hour by each unit (AM) can be expressed as:

$$AM = PS \times f_u \tag{D.2.6}$$

where AM, **PS,** and f_u are defined above. Replacing **AM** in **(D.2.5)** with **(D.2.6)** yields formula **(D.2.1).** For computational purposes, however, it is advantageous to express the fraction of time spent on uncommitted time as:

$$f_u = \frac{m_u}{60} \tag{D.2.7}$$

where m_u represents the average number of minutes per hour spent on uncommitted time by each unit. Dividing m_u by **60** yields the fraction of time spent on uncommitted time. Replacing f_u in **(D.2.6)** with **(D.2.7)** yields:

$$AM = PS \times \frac{m_u}{60} \tag{D.2.8}$$

Replacing AM in **(D.2.5)** with **(D.2.8)** yields the final expression for **PI:**

$$PI = \frac{HM}{PS \times \dfrac{m_u}{60} \times N} \qquad (D.2.9)$$

Derivation of the Number of Officers (N_{ppi}) Required to Meet the Patrol Interval Performance Objective

To determine how many officers are needed to achieve a particular patrol interval performance objective for a particular roadway type requires solving **(D.2.9)** for **N;** i.e.,

$$N = \frac{HM}{PS \times \dfrac{m_u}{60} \times PI} \qquad (D.2.10)$$

To obtain the minimum number of units, let $m_u = 60$ which reduces **(D.2.10)** to:

$$N = \frac{HM}{PS \times PI} \qquad (D.2.11)$$

Formula **(D.2.11)** indicates the minimum number of patrol units that would be needed to meet the patrol interval objective.

Formula **(D.2.11)** is based on the assumption that the roadway system is patrolled **24** hours a day everyday (i.e., **168** hours per week). To account for reduced coverage (i.e., for coverage that is less than **168** hours per week), multiply formula **(D.2.11)** by WC/168; that is,

$$N \ = \ \frac{HM}{PS \ x \ PI} \ x \ \frac{WC}{168} \tag{D.2.12}$$

where **WC** represents the total hours of coverage per week.

To determine the number of on-duty officers that will be required **per day (N_{ppi})**, use the relationship:

$$N_{ppi} \ = \ N \ x \ \frac{24}{S_l} \tag{D.2.13}$$

where:

    N - number of patrol units given in **(D.2.12)**, and

    S_l - shift length in hours.

Substituting **(D.2.12)** for N in **(D.2.13)** and simplifying yields:

$$N_{ppi} \ = \ \frac{HM \ x \ WC}{7 \ x \ PS \ x \ S_l \ x \ PI} \tag{D.2.14}$$

which is the formula used in Section **5.1 to** determine the number of officers required to meet patrol interval performance objectives for **a particular** roadway type.

APPENDIX **D.3:** <u>Total Number of Officers **(N_{pir})** Required Per **Day**</u> <u>Within the **APA** To Provide Immediate Response To</u> <u>the Performance Objective Percentage of **CFS,**</u> <u>Accidents, Administrative, and Self-Initiated</u> <u>Activities (Section **5.2)**</u>

<u>Introduction</u>

In the PAM model, the appearance and servicing of **CFS,** accidents, administrative, and self-initiated activities are treated as a simple multiserver queuing process. These activities are assumed to occur randomly (i.e., as a Poisson process) and the service times required to complete these activities are assumed to be independent and exponentially distributed.

The term "exponentially-distributed service **times"** describes the particular mathematical distribution or formula that is used to describe the nature of the service times **(e.g.,** what would the histogram of a sample of service times look like). A key property of exponentially-distributed service times is that the likelihood (or probability) of service time t_1 will be less than the likelihood (or probability) of service time t_2 if $t_1 > t_2$. This property implies that the individual bars in the histogram of sample service times will be smaller **for** longer service times. Field experience indicates that exponentially-distributed service times are appropriate for describing many operations; for example, the lengths of telephone calls, the times required to complete transactions with bank tellers, the times required to checkout at grocery stores, and the average service times associated with dispatched **CFS.**

In a standard, steady-state queuing formulation with these assumptions and a fixed number of servers (i.e., a fixed number of patrol officers), the average number of busy officers at any given time **(N_b)** is given by:

$$N_b = CR \; \textbf{x} \; ST \tag{D.3.1}$$

where **CR** represents the number of activities per hour and ST represents the average service time in hours.

The likelihood or probability that all of the officers will be busy (**P_{sat}**) when the next activity occurs is called the "probability of **saturation**" and is given by **Erlang's** formula found in many introductory texts on queuing theory:

$$P_{sat} = \frac{N_b{}^{N_t}}{N_t! \times (1 - N_b/N_t)} \times P_o \qquad \text{(D.3.2)}$$

where N_t represents the total number of officers in the area and the term **$N_b{}^{N_t}$** represents **N_b** raised to the **N_t th** power, and

$$P_o = \left[\sum_{k=0}^{N_t-1} \frac{N_b{}^k}{k!} + \frac{N_b{}^{Nt}}{N_t! \times (1 - N_b/N_t)} \right]^{-1} \qquad \text{(D.3.3)}$$

Note that unless **N_t** equals or exceeds **N_b,** there will not be enough officers to handle the workload and the system will be continuously "saturated;" that is, the queue (or stack) will grow larger and larger. Readers who wish to examine the derivation of these formulas are referred to any standard text on **queueing** theory or operations research such as <u>Introduction to Operations Research</u> by Hillier and Lieberman (Holden-Day, Inc., **1967).**

The likelihood or probability that at least one officer will be available (**P_{avail}**) when the next activity occurs is given by:

$$P_{avail} = 1 - P_{sat} \qquad \text{(D.3.4)}$$

This derivation is presented in two parts. In the next section, the general methodology for determining how many officers are needed to meet the immediate response performance objective when no activities are preemptable is presented. The following section expands the methodology to include the use of both preemptable and non-preemptable activities.

No Preemptable Activities

The total number of officers (N_t) available for reactive, adminis-
trative, and self-initiated activities consists of the total number
of on-duty officers for reactive activities (N_r), administrative
activities (N_a), self-initiated activities (N_s), and uncommitted
patrol (N_p); i.e.,

$$N_t = N_r + N_a + N_s + N_p \qquad (D.3.5)$$

The number of on-duty officers required for administrative and
self-initiated activities per day can be expressed as a function of
the number of on-duty officers required per day for reactive
activities (NJ, the number of on-duty officers required per day for
uncommitted patrol activities (NJ, the average number of minutes
of administrative time per hour per officer (m_a), and the average
number of minutes per hour per officer spent on self-initiated
activities (m_s). In the PAM model, the number of officers assigned
to each category: administrative, reactive, self-initiated, and
uncommitted patrol is proportional to the time spend per hour on
each activity; i.e.,

$$\frac{N_a}{N_t} = \frac{m_a}{60}, \qquad \frac{N_r}{N_t} = \frac{m_r}{60}$$

$$(D.3.6)$$

$$\frac{N_s}{N_t} = \frac{m_s}{60}, \qquad \frac{N_p}{N_t} = \frac{m_p}{60}$$

'where:

m_r - **average** number of minutes spend **per hour per**
officer on reactive activities,

m_p - average number of minutes spend **per hour per**
officer on uncommitted patrol activities,

and

$$60 = m_r + m_p + m_a + m_s .$$ (D.3.7)

Rearranging the terms in **(D.3.6)** yields:

$$\frac{N_a}{m_a} = \frac{N_s}{m_s} = \frac{N_r}{m_r} = \frac{N_p}{m_p} = \frac{N_t}{60}$$ (D.3.8)

Noting that the following is true:

$$\frac{N_r + N_p}{m_r + m_p} = \frac{N_t}{60}$$ (D.3.9)

and combining **(D.3.8)** and **(D.3.9)** yields:

$$\frac{N_a}{m_a} = \frac{N_s}{m_s} = \frac{N_r + N_p}{m_r + m_p} .$$ (D.3.10)

Using **(D.3.7)** to replace $m_r + m_p$ with $60 - m_a - m_s$ in **(D.3.10)** yields:

$$\frac{N_a}{m_a} = \frac{N_s}{m_s} = \frac{N_r + N_p}{60 - m_a - m_s}$$ (D.3.11)

Using **(D.3.11)** to solve for N_a and N_s yields:

$$N_a = K_a \times (N_r + N_p)$$ (D.3.12)

and

$$N_s \ = \ K_s \ \mathbf{x} \ (N_r \ + \ N_p) \tag{D.3.13}$$

where $\mathbf{K_a}$ and $\mathbf{K_s}$ equal:

$$K_a \ = \ \frac{m_a}{60 \ - \ m_a \ - \ m_s} \tag{D.3.14}$$

and

$$K_s \ = \ \frac{m_s}{60 \ - \ m_a \ - \ m_s} \tag{D.3.15}$$

Replacing $\mathbf{N_a}$ and $\mathbf{N_s}$ in **(D.3.5)** with **(D.3.12)** and **(D.3.13)** and rearranging yields:

$$N_t \ = \ N_r \ + \ K_a \ \mathbf{x} \ (N_r \ + \ N_p) \ + \ K_s \ \mathbf{x} \ (N_r \ + \ N_p) \ + \ N_p \tag{D.3.16}$$

The right side of formula **(D.3.16)** consists of four terms. The first three terms: $\mathbf{N_r}$, $\mathbf{K_a}$ **x** $(\mathbf{N_r + N_p})$, and $\mathbf{K_s}$ **x** $(\mathbf{N + N_p})$ represent the officers that are busy on reactive, administrative, and self-initiated activities; i.e.,

$$N_b \ = \ N_r \ + \ K_a \ \mathbf{x} \ (N_r \ + \ N_p) \ + \ K_s \ \mathbf{x} \ (N_r \ + \ N_p) \tag{D.3.17}$$

where $\mathbf{N_r}$ represents the officers on reactive activities, $\mathbf{K_a}$ **x** $(\mathbf{N_r + N_p})$ represents the officers on administrative **activities, and** $\mathbf{K_s}$ **x** $(\mathbf{N_r + N_p})$ represents the officers on self-initiated activities. The only officers represented in formula in **(D.3.16)** that are not busy are represented by $\mathbf{N_p}$. If no on-duty officers are provided for uncommitted patrol activities **(i.e,** if $\mathbf{N_p = 0}$), then $N_t = N_r +$ $(\mathbf{K_a} \ \mathbf{x} \ \mathbf{N_r})$ **+** $(\mathbf{K_s} \ \mathbf{x} \ \mathbf{N_r})$ and all officers in the field will be busy. This is the <u>minimum</u> number of officers required **to handle these** activities. Hence, by definition, **if only** $N_r + (K_a \ \mathbf{x} \ N_r) + (K_s \ \mathbf{x} \ N_r)$

officers are available, every officer will be busy for **60** minutes an hour (**i.e., $P_{sat} = 1$ and $P_{avail} = 0$**).

As officers are added for uncommitted patrol activities (i.e., as N_p becomes greater than zero), N_t increases and the hourly reactive, administrative, and self-initiated workload for each officer becomes less than **60** minutes per hour. As this happens, P_{sat} decreases and P_{avail} increases. As more officers are added, P_{avail} increases until it equals or exceeds the immediate response performance objective expressed as a probability (**P_{obj}**); that is, N_p is increased until

$$P_{avail} \geq P_{obj} \tag{D.3.18}$$

where:

$$P_{obj} = \frac{\text{PIR\%}}{100}$$

and **PIR%** represents the immediate response performance objective expressed as percent entered by the user in Section **5.2**.

Preemptable Activities

The total number of officers (**N_t**) available for reactive, administrative, and self-initiated activities consists of the total number of on-duty officers for reactive activities (**N_r**), administrative activities (**N_a**), self-initiated activities (**N_s**), uncommitted patrol (NJ ; i.e.,

$$N_t = N_r + N_a + N_s + N_p \tag{D.3.19}$$

If reactive, administrative, and self-initiated activities are preemptable, (**D.3.19**) can be rewritten as:

$$N_t = f_{npr} \times N_r + (1-f_{npr}) \times N_r + f_{npr} \times N_a +$$

$$(1-f_{npa}) \times N_a + f_{nps} \times N_s + (1-f_{nps}) \times N_s + N_p \tag{D.3.20}$$

where:

f_{npr} — fraction of reactive activities that are not preemptable,

f_{npa} — fraction of administrative activities that are not preemptable, and

f_{nps} — **fraction of self-initiated** activities that are not preemptable.

Substituting **(D.3.12)** and **(D.3.13)** for N_a and N_s in **(D.3.20)** and rearranging yields:

$$N_t = f_{npr} \times N_r + f_{npr} \times K_a \times (N_r + N_p) + f_{nps} \times K_s \times (N_r + N_p) +$$

$$(1-f_{npr}) \times N_r + (1-f_{,,}) \times K_a \times (N_r + N_p) +$$

$$(1-f_{nps}) \times K_s \times (N_r + N_p) + N_p \qquad (D.3.21)$$

Expression **(D.3.21)** can be rewritten as:

$$N_t = f_{npr} \times N_r + K_{na} \times (N_r + N_p) + K_{ns} \times (N_r + N_p) +$$

$$(1-f_{npr}) \times N_r + K_a \times (N_r + N_p) - K_{na} \times (N_r + N_p) +$$

$$K_s \times (N_r + N_p) - K_{ns} \times (N_r + N_p) + N_p \qquad (D.3.22)$$

where:

$$K_{na} = f_{npr} \times K_a \qquad \text{and} \qquad K_{ns} = f_{nps} \times K_s.$$

Expression **(D.3.22)** can be further simplified as:

$$N_t = f_{npr} \times N_r + K_{nsa} \times (N_r + N_p) + (1-f_{npr}) \times N_r +$$

$$K_{sa} \times (N_r + N_p) - K_{nsa} \times (N_r + N_p) + N_p \qquad (D.3.23)$$

where:

$$K_{sa} = K_a + K_s \qquad \text{and} \qquad K_{nsa} = K_{na} + K_{ns}.$$

The first two terms on the right side of the equal sign in **(D.3.23)** represent the officers that are busy **(N_b)** on non-preemptable reactive, administrative, and self-initiated activities; i.e.,

$$N_b = f_{npr} \times N_r + K_{nsa} \times (N_r + N_p).$$ (D.3.24)

The last four terms on the right side of the equal sign are the officers that are available or free **(N_f)** either because they are on uncommitted patrol or on a preemptable **activitie;** i.e.

$$N_f = (1-f_{npr}) \times N_r + K_{sa} \times (N_r + N_p) - K_{nsa} \times (N_r + N_p) + N_p$$ (D.3.25)

PAM **Methodology**

Because of the complexity of formulas **(D.3.2)** and **(D.3.3)**, it is not possible to derive a closed expression for **N_p** based on **N_r, K_{sa}, K_{nsa},** and **P_{obj}**. To overcome this difficulty, the PAM manual uses a table look-up procedure. Appendix A in the Manual contains a series of tables for determining the total number of officers **(N_f)** that must be available to satisfy the immediate response performance objective. Each table is based on a specific **K_{nsa}** value. Within the table, **N_{rs}** (the average number of on-duty officers for reactive activities per shift) and **PIR%** values are used to find the appropriate **N_f** value. In Section **5.2,** the procedure is based on two **simplfying** assumptions: **(1)** that staffing is uniform over all shifts, and **(2)** that the same immediate response performance objective is used for each shift. The steps in the procedure are outlined below.

Step **1.** Determine the average number of on-duty offi-
cers for reactive activities per shift **(N_{rs})** in
steps **(5.2.1.1)** through **(5.2.2.2)**.

Step **2.** Determine an adjusted number of on-duty offi-
cers **(N_{ns})** for reactive activities in steps
(5.2.2.3) through **(5.2.2.16)**. The adjusted
number of officers is determined based with the
formula:

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$$N_{ns} = \frac{N_{rs} \times (f_{npr} + K_{nsa})}{1 + K_{nsa}} \qquad (D.3.26)$$

Formula **(D.3.26)** is based on the observation that the number of busy officers given in **(D.3.24)** is a function of three variables: N_{rs}, K_{nsa}, and f_{npr}. To use the table lookup procedure, however, only the number of officers (N_{rs}) and the K_{nsa} value are needed. To eliminate the f_{npr} variable, an adjusted number of officers is used. The formula for the adjusted number is obtained by finding the value of N_{ns} that satisfies the relationship:

$$N_{ns} + K_{nsa} \times (N_{ns} + N_p) = f_{npr} \times N_{rs} + K_{nsa} \times (N_{rs} + N_p)$$

$$(D.3.27)$$

Step **3.** 'Use K_{nas} to select the appropriate table. (Step 5.2.3)

Step **4.** Select an immediate response performance objective percent **(PIR%)**. (Step **5.2.4.1)**.

Step **5.** Use N_{ns} and **PIR%** in the table selected to determine the total number of officers that are needed to meet the immediate response performance objective (N_f).

Step **6.** The actual number of officers needed to meet the immediate response performance objective (N_{pir}) will less than N_f if some officers are available on preemptable activities. To determine N_{pir}, the total number of available officers given in **(D.3.25)** is set equal to N_f. The N_p term in the equation equals N_{pir} and is given by:

$$N_{pir} = \frac{N_f - N_r \times (1 - f_{npr} + K_{dsa})}{1 + K_{dsa}} \qquad (D.3.28)$$

If the value for N_{pir} is less than zero, this indicates that there are enough officers available on preemptable activities to meet the immediate response performance objective.

Step **7.** The total number of on-duty officers for the immediate response requirement is obtained by multiplying the average number required per shift by the effective number of shifts per day,

If either of the two simplifying assumptions used in Section **5.2** are not valid, the user can use the supplemental worksheet in Appendix A in the Manual to estimate N_{pir}. The worksheet uses the procedure described above for each shift. The number of officers required is determined separately for each shift and the results are added together to obtain the total **daily on-duty** requirement

The values in tables A-1 through **A-13** were determined using formulas **(D.3.2), (D.3.3), (D.3.4),** and **(D.3.16)** with the following logic:

- For a range of values **(0.10 - 20.00)** for the average number of on-duty officers for reactive, administrative, and self-initiated activities on each shift **(N_{rs})** and a range of values **(0.05 - 1.25)** for K_{nsa}, calculate P_{avail} values for integer values of N_t beginning with the smallest value of N_t such that $N_t \geq N_{rs}$.

- For each value of N_t, determine the number of officers available **(N_f)** based on **(D.3.25)**; i.e.,

$$N_f = \frac{N_t - (1 + K_{nsa}) \times N_r}{(1 + K_{nsa})} \qquad \text{(D.3.29)}$$

Increase N_t until $P_{avail} \geq .995$.

- Estimate N_f for specific values of N_{rs}, P_{avail}, and K_{nsa} by interpolating between the calculated values for N_f and P_{avail} for specific values for K_{nsa}. Each value of K_{nsa} represents a separate table in Appendix A. Within each table, each estimated value for N_f corresponds to specific values for N_{rs} and P_{avail}.

APPENDIX **D.4:** <u>Average Number of **On-Duty** Officers **(N$_{pap}$)** Required Within the **APA** To Meet the Average Travel Time Performance **Objective** for Emergency and **Non-Emergency CFS** (Sections **5.3** and **5.4)**</u>

<u>Travel Times for Non-Emergency **CFS**</u>

In Section **5.4,** the average number of on-duty officers required per day to meet the travel time performance objective for non-emergency activities is given **by:**

$$N_{nett} = \left[\frac{40}{PTT \times RS}\right]^2 \times \frac{A \times WC}{7 \times S_l} \qquad (D.4.1)$$

where:

    N_{nett} —   average number of officers required to meet the travel time performance objective for **non-**emergency activities,

    A   —   area (square miles) of the **APA,**

    WC   —   coverage (hours) per week,

    NS   —   number of shifts per day,

    PTT   —   average travel time (minutes) performance objective,

    RS   —   average response speed (MPH), and

    S$_l$ —   shift length (hours),

Formula **(D.4.1)** is based on the **"square** root **law"** which can be used to estimate the average travel distance **(D)** for a responding police unit in an area of size A with N available units. The generic formula is given by:

$$D = K \times \frac{\sqrt{A}}{\sqrt{N}} \tag{D.4.2}$$

where:

D - average distance (miles),

K - a constant based on **the geography of the area,**

A - the **area** of the region **(square miles), and**

N - the number of police units available.

Using the time **(T),** speed **(S),** and distance **(D)** relationship from basic physics; i.e.,

$$T = \frac{D}{S} \tag{D.4.3}$$

and replacing D in **(D.4.3)** with **(D.4.2)** yields:

$$T = \frac{K \times \sqrt{A}}{S \times \sqrt{N}} \tag{D.4.4}$$

Under certain conditions, Larson (<u>Urban Police Patrol Analysis</u>, MIT Press, **1972)** found that a value of **2/3** for the constant in **(D.4.2)** gives good results. (Key conditions are relatively low workload levels, uniformity of workload over the area, and approximately equal travel times in all directions.) Putting **2/3** in for **K** in formula **(D.4.4)** and multiplying by **60** to change travel time to minutes yields:

$$T = \frac{60 \times 2 \times \sqrt{A}}{3 \times S \times \sqrt{N}} \tag{D.4.5}$$

Simplifying expression **(D.4.5)** yields:

$$T = \frac{40 \times \sqrt{A}}{S \times \sqrt{N}} \qquad \text{(D.4.6)}$$

Solving formula **(D.4.6)** for N yields:

$$N = \left[\frac{40}{T \times S} \right]^2 \times A \qquad \text{(D.4.7)}$$

Replacing speed **(S)** with the average response speed **(RS)** and time **(T)** with the average travel time performance objective **(PTT)** yields:

$$N = \left[\frac{40}{PTT \times RS} \right]^2 \times A \qquad \text{(D.4.8)}$$

which indicates the number of patrol units required to meet the non-emergency travel time performance objective.

Formula **(D.4.8)** is based on the assumption that the area is **patroled 24** hours a day, 7 days a week (i.e., **168** hours per week). To account for reduced coverage (i.e., less than **168** hours per week), **(D.4.8)** can by multiplied by **WC/168;** that is,

$$N = \left[\frac{40}{PTT \times RS} \right]^2 \times A \times \frac{WC}{168} \qquad \text{(D.4.9)}$$

where **WC** represents the total hours of coverage per week.

Since each patrol unit represents one officer, the total number of officers needed per day for area patrol is given by:

$$N_{nett} = N \times \frac{24}{S_l} \qquad \text{(D.4.10)}$$

where N is the number of units calculated in **(D.4.9)** and S_l is the shift length in hours. Replacing N in **(D.4.10)** with **(D.4.9)** and simplifying yields:

$$N_{nett} = \left[\frac{40}{PTT \times RS} \right]^2 \times \frac{A \times WC}{7 \times S_l} \qquad \text{(D.4.11)}$$

which is the formula given in **(D.4.1)**. In Section **5.3,** coverage is assumed to be **168** hours per week (i.e., WC = **168).** Using this value in **(D.4.11)** yields:

$$N_{nett} = \left[\frac{40}{PTT \times RS} \right]^2 \times \frac{24 \times A}{S_l} \qquad \text{(D.4.12)}$$

Travel Times for **Emergency CFS**

The discussion above for non-emergency **CFS** assumes that officers on reactive, administrative, and self-initiated activities cannot be reassigned until the activity is complete. For travel times to emergency activities, the PAM permits the user to indicate what fraction of reactive, administrative, and self-initiated activities can be preempted. Officers on preemptable activities become part of the pool of officers who are available for emergency **CFS.**

Section **5.3** is used to determine the number of additional officers on uncommitted patrol **(N_{ett})** to satisfy the emergency activity travel time requirement.

The total number of officers (NJ available for reactive adminis-
trative, and self-initiated activities consists of the total number
of on-duty officers for reactive activities **(N_r),** administrative
activities **(N_a),** self-initiated activities (NJ, uncommitted patrol
(N_p); i.e.,

$$N_t = N_r + N_a + N_s + N_p \qquad (D.4.13)$$

If reactive, administrative, and self-initiated activities are
preemptable, **(D.4.13)** can be rewritten as:

$$N_t = f_{npr} \times N_r + (1-f_{npr}) \times N_r + f_{npr} \times N_a +$$

$$(1-f,) \times N_a + f_{nps} \times N_s + (1-f_{nps}) \times N_s + N_p \qquad (D.4.14)$$

where:

f_{npr} — fraction of reactive activities that are not
preemptable,

f_{npa} — fraction of administrative activities that are
not preemptable, and

f_{nps} — fraction of self-initiated activities that are
not preemptable.

Substituting **(D.3.12)** and **(D.3.13)** for N_a and N_s in **(D.4.14)** and
rearranging yields:

$$N_t = {}^{\prime\prime}f_{npr} \times N_r + f_{npr} \times K_a \times (N_r + N_p) + f_{nps} \times K_s \times (N_r + N_p) +$$

$$(1-f_{npr}) \times N_r + (1-f_{npa}) \times K_a \times (N_r + N_p) +$$

$$(1-f_{nps}) \times K_s \times (N_r + N_p) + N_p \qquad (D.4.15)$$

Expression **(D.4.15)** can be rewritten as:

$$N_t = f_{npr} \times N_r + K_{na} \times (N_r + N_p) + K_{ns} \times (N_r + N_p) +$$
$$(1-f_{npr}) \times N_r + K_a \times (N_r + N_p) - K_{na} \times (N_r + N_p) +$$
$$K_s \times (N_r + N_p) - K_{ns} \times (N_r + N_p) + N_p \qquad (D.4.16)$$

where:

$$K_{na} = f_{npr} \times K_a \qquad \text{and} \qquad K_{ns} = f_{nps} \times K_s.$$

Expression (D.4.16) can be further simplified as:

$$N_t = f_{npr} \times N_r + K_{nsa} \times (N_r + N_p) + (1-f_{npr}) \times N_r +$$
$$K_{sa} \times (N_r + N_p) - K_{nsa} \times (N_r + N_p) + N_p \qquad (D.4.17)$$

where:

$$K_{sa} = K_a + K_s \qquad \text{and} \qquad K_{nsa} = K_{na} + K_{ns}.$$

The first two terms on the right side of the equal sign in (D.4.17) represent the officers that are busy (N_b) on non-preemptable reactive, administrative, and self-initiated activities; i.e.,

$$N_b = f_{npr} \times N_r + K_{nsa} \times (N_r + N_p) . \qquad (D.4.18)$$

The last four terms on the right side of the equal sign are the officers that are available or free (N_f) either because they are on uncommitted patrol or on a preemptable **activitie;** i.e.

$$N_f = (1-f_{npr}) \times N_r + K_{sa} \times (N_r + N_p) - K_{nsa} \times (N_r + N_p) + N_p$$
$$(D.4.19)$$

The PAM procedure for determining the number of additional officers on uncommitted time that are needed to meet the travel time performance objective for emergency activities is based on the following steps.

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Step 1. Using **(D.4.9)**, determine the total number of officers required **(N)** to meet the travel time requirement.

Step 2. Set N equal to the total number of available officers given by **(D.4.19)**. Determine the additional number of officers **(N_{ett})** needed by solving by **Np** and setting **$N_{ett} = N_p$;** i.e.,

$$N_p = \frac{N - N_r \times (1 - f_{npr} + K_{dsa})}{1 + K_{dsa}} \quad \text{(D.4.20)}$$

Step 3. Multiply **N_{ett}** by the number of effective shifts per day to obtain the total number of additional officers needed to meet the travel time requirement.

APPENDIX D.5: <u>Average Total Number of **On-Duty** Officers **(N)**</u>
<u>Required Per **Day** for All Patrol Activities</u>
<u>Within the **APA**, One Officer Per Unit (Section **6.1)**</u>

<u>Introduction</u>

The basic **formula** in the PAM model, used to derive the average
daily number of on-duty officers, is given by:

$$N = \frac{N_r + N_p}{1 - \dfrac{m_a}{60} - \dfrac{m_s}{60}} \qquad \text{(D.5.1)}$$

where:

- N - the average number of on-duty officers per day
  (i.e., per **24-hour** period),

- N_r - the average number of on-duty officers required
  per day for reactive activities,

- N_p - the average number of on-duty officers required
  per day for uncommitted patrol activities,

- m_a - average number of minutes spend per hour per
  officer on administrative activities, and

- m_s - average number of minutes spend per hour per
  officer on self-initiated activities.

<u>Four Workload Components</u>

Derivation of formula **(D.5.1)** is based on the assumption that the
average total number of on-duty officers required per day **(N)**
consists of four components; that is,

$$N \quad = \quad N_r \quad + \quad N_p \quad + \quad N_s \quad + \quad N_a \qquad\qquad (D.5.2)$$

where N_t, N_r, and N_p are defined above and

N_s — the average number of on-duty officers required per day for self-initiated activities, and

N_a — the average number of on-duty officers required per day for administrative activities.

Much of the PAM model is devoted to determining each of the four components identified above. The procedure for each component is presented below.

Reactive and uncommitted patrol activities. In the PAM model, the number of on-duty officers required per day for reactive activities (N_r) depends on two variables: (1) the total obligated time per day and (2) the shift length of the agency. Neither measure is dependent upon the total number of officers (N) that are present. The number of on-duty officers required per day for uncommitted patrol activities (N_p) is based on the **"availability"** of officers for reactive, administrative, and self-initiated activities and officer **visibility@' for deterrence. The PAM model offers several options for determining N_p. Regardless of which option is used, none are dependent of the total number of on-duty officers (N). Hence, for both reactive and uncommitted patrol activities, all of the workload measures used to estimate N_r and N_p are independent of the total number of officers on patrol. As a result, values for N_r and N_p can be obtained using historical data regardless of the staffing levels of the agency in the past.

Self-initiated and administrative activities. In contrast to the procedures used to determine N_r and N_p, the workload measures used to determine N_s and N_a in the PAM model are not independent of the number of on-duty officers (N) that are **present.** For most law enforcement agencies the amount of work that is recorded for administrative and self-initiated activities is, in fact, directly related to how many officers are on-duty. The validity of this assertion is based on the following observations:

● Every officer has activity time that does not fall into the reactive, self-initiated, or uncommitted patrol category. Collectively referred to as administration, the amount of time is usually independent of how many officers are on patrol. As a result, the

total administrative time for an agency is not fixed, but increases or decreases as the number of officers changes.

- The total time spent on self-initiated activities is usually highly correlated to the number of officers in the field; **that** is, as the number of officers increases, the amount of self-initiated work increases. This occurs because the fraction of self-initiated work that is actually performed with existing patrol resources usually represents only a small fraction of the total self-initiated work possible. As a result, regardless of how many additional officers are placed on patrol, there is always more self-initiated work to be done than can actually be accomplished.

Determination of N_s and N_a

The dependency of N_s and N_a upon the average total number of on-duty officers per day **(N)** can be expressed as:

$$N_s \quad = \quad f_s \ \times \ N \tag{D.5.3}$$

and

$$N_a \quad = \quad f_a \ \times \ N \tag{D.5.4}$$

where:

f_s — fraction of time spend on self-initiated activities, and

f_a — fraction of time spend on administrative activities.

Inserting expressions **(D.5.3)** and **(D.5.4)** into **(D.5.2)** above yields:

$$N \ = \ N_r \ + \ N_p \ + \ (f_s \ \times \ N) \ + \ (f_a \ \times \ N) \tag{D.5.5}$$

Solving **(D.5.5)** for N yields:

$$N = \frac{N_r + N_p}{1 - f_s - f_a} \qquad \text{(D.5.6)}$$

The fractions **f$_s$** and **f$_a$** can be expressed as:

$$f_s = \frac{m_s}{60} \qquad \text{(D.5.7)}$$

and

$$f_a = \frac{m_a}{60} \qquad \text{(D.5.8)}$$

where **m$_s$** and **m$_a$** are defined above. Placing expressions **(D.5.7)** and **(D.5.8)** into formula **(D.5.5)** yields the basic PAM formula:

$$N = \frac{N_r + N_p}{1 - \dfrac{m_a}{60} - \dfrac{m_s}{60}} \qquad \text{(D.5.9)}$$

APPENDIX **D.6**: <u>Average Total Number of On-Duty Officers **(N$_0$)**</u>
<u>Required Per **Day** for All Patrol Activities Within</u>
<u>the **APA**, Adjusted for One and Two Officer Units</u>
<u>(Section **6.2**)</u>

Determination of the total number of on-duty officers required per day **(N$_0$)** is based on:

- the average total number of patrol units needed per day **(N)** , and

- the percent of patrol units that are staffed with two officers **(P2T%)**.

The average total number of patrol units needed per day **(N)** is equal to the average total number of on-duty officers needed each day <u>if every patrol unit is staffed with **only** one officer</u>. The number of on-duty officers required per day is calculated in Section **6.1** of the PAM manual. (The derivation for the formula used in Section **6.1** is given in Section **D.5** above.)

The percent of patrol units that are staffed with two officers **(P2T%)** is specified by the PAM user. Based on **P2T%,** define

$$ f \quad = \quad \frac{\textbf{P2T\%}}{\textbf{100}} \qquad\qquad (D.6.1) $$

where **f** represents the fraction of units staffed with two officers. Using N and **f,** let

$$ N_2 \quad = \quad f \ \textbf{X} \ N \qquad\qquad (D.6.2) $$

where **N$_2$** represents the number of patrol units per day that are staffed with two officers. If **N$_1$** represents the number of patrol units per day that are staffed with one officer, then

$$N \quad = \quad N_1 \quad_+ \quad N_2 \qquad\qquad\qquad (D.6.3)$$

Solving **(D.6.3)** for N_1 and replacing N_2 with **(D.6.2)** yields

$$N_1 \quad = \quad N \quad - \quad N_2$$

$$N_1 \quad = \quad N \quad - \quad (f \ x \quad N)$$

$$N_1 \quad = \quad (1 - f) \quad x \quad N \qquad\qquad\qquad (D.6.4)$$

The total number of on-duty officers is given by

$$N_o \quad = \quad 1 \ x \ N_1 \quad + \quad 2 \ x \ N_2 \qquad\qquad\qquad (D.6.5)$$

Replacing N_1 with **(D.6.4)** and N_2 with **(D.6.2)** in **(D.6.5)** and rearranging yields:

$$N_o \quad = \quad 1 \ x \ (1 - f) \ x \ N \ + \ 2 \ x \ (f \ x \ N)$$

$$N_o \quad = \quad (1 + f) \ x \ N \qquad\qquad\qquad (D.6.6)$$

Formula **(D.6.6)** is used in Section **6.2.**

Appendix **D.7**:   <u>Average Total Number of On-Duty Officers **(N**ot**)** and</u>
<u>On-Duty Field **Supervisors (N**os**)** Required Per **Day** for</u>
<u>Patrol Activities Within the **APA, Adjusted** for the</u>
<u>Presence of Field **Supervisors** and Special</u>
<u>**Assignment** Personnel (Worksheet 7)</u>

<u>Introduction</u>

The adjusted number of on-duty officers required per day **(N**ot**)** is
based on the formula:

$$N_{ot} = K_f \times \left[N_0 + N_{s1} \times f_{s1} + N_{s2} \times f_{s2} + N_{s3} \times f_{s3} \right] \quad (D.7.1)$$

where:

$$K_f = \frac{s}{s + f},$$

and

N_0 - the unadjusted number of on-duty officers
required per day determined in Section **6.1;**

s - the average span of control for field
supervisors (i.e., the average number of
officers supervisedby each field supervisor
specified by the PAM user in Worksheet **1;**

f - the fraction of supervisor on-duty time
spent on patrol activities (i.e., non-super
visory activities);

f_{s1}, f_{s2}, f_{s3} - the fraction of on-duty time officers as
signed to special units spend on non-patrol
activities; and

N_{s1}, N_{s2}, N_{s3} - the number of officers assigned to special
assignments **1, 2,** and 3 specified by the PAM
user.

The number of on-duty field supervisors required **(N_{os})** is given by:

$$N_{os} = \frac{N_{ot}}{s} \qquad\qquad\text{(D.7.2)}$$

Derivation of the Formula for the **Adjusted** Number of **On-Duty** Officers **(N_{ot})**

If the percent of field supervisor on-duty time **($F_{s\%}$)** spent on patrol activities is known, the fraction **(f)** can be determined as:

$$f = \frac{F_{s\%}}{100} \qquad\qquad\text{(D.7.3)}$$

The percent **$F_{s\%}$** is specified by the PAM user in Worksheet **1.**

If the percents of on-duty time **($S_{\%1}$, $S_{\%2}$, and $S_{\%3}$)** that officers assigned to special assignments **1, 2,** and 3 respectively spend on patrol activities are known, the fractions **(f_{s1}, f_{s2}, and f_{s3})** can be determined as:

$$f_{s1} = \frac{100 - S_{\%1}}{100} ,$$

$$f_{s2} = \frac{100 - S_{\%2}}{100} , \text{ and}$$

$$f_{s3} = \frac{100 - S_{\%3}}{100} .$$

The percents $S_{\%1}$, $S_{\%2}$, and $S_{\%3}$ are supplied by the PAM user in Worksheet **7.**

The derivation of formula **(D.7.1)** depends on the observation that regardless of the values for s, $F_{s\%}$, N_{s1}, N_{s2}, N_{s3}, $S_{\%1}$, $S_{\%2}$, and $S_{\%3}$ provided by the user, the total number of **"full-time** equivalent" on-duty officers required per day after adjusting for the presence of field supervisors and officers assigned to special units must equal the number of unadjusted on-duty officers required per day **(N_o)** determined in Worksheet **6;** that is:

$$N_0 = N_{aft} + f \times N_{os} + g_{s1} \times N_{s1} + g_{s2} \times N_{s2} + g_{s3} \times N_{s3}$$

$$(D.7.7)$$

where:

N_{aft} — the adjusted number of on-duty officers <u>not</u> assigned to a special unit;

$f \times N_{os}$ — the full-time equivalent number of officers for patrol that will be provided by the presence of the N_{os} field supervisors;

g_{s1}, g_{s2}, g_{s3} — the fraction of on-duty time officers assigned to special units **1, 2,** and 3 respectively spend on patrol activities;

$g_{s1} \times N_{s1}$ — the full-time equivalent number of officers for patrol that will be provided by the presence of the N_{s1} officers assigned to special assignment **1;**

$g_{s2} \times N_{s2}$ — the full-time equivalent number of officers for patrol that will be provided by the presence of the N_{s2} officers assigned to special assignment **2;** and

$g_{s3} \times N_{s3}$ — the full-time equivalent number of officers for patrol that will be provided by the presence of the N_{s3} officers assigned to special assignment **3.**

Replacing N_{os} in **(D.7.7)** with formula **(D.7.2)** yields:

$$N_0 = N_{aft} + f \times \frac{N_{ot}}{s} + g_{s1} \times N_{s1} + g_{s2} \times N_{s2} + g_{s3} \times N_{s3}$$

$$(D.7.8)$$

The term N_{ot} can be expressed as:

$$N_{ot} = N_{aft} + N_{s1} + N_{s2} + N_{s3} \qquad (D.7.9)$$

Solving **(D.7.9)** for N_{aft} yields:

$$N_{aft} = N_{ot} - N_{s1} - N_{s2} - N_{s3} \; . \qquad (D.7.10)$$

Replacing N_{aft} in **(D.7.8)** with **(D.7.10)** and solving for N_{ot} yields:

$$N_{ot} = K_f \times \left[N_0 + N_{s1} \times (1-g_{s1}) + N_{s2} \times (1-g_{s2}) + N_{s3} \times (1-g_{s3}) \right.$$

$$(D.7.11)$$

where:

$$K_f = \frac{s}{s + f}$$

Formula **(D.7.11)** can be further simplified by noting that

$$g_{s1} + f_{s1} = 1 , \qquad g_{s2} + f_{s2} = 1 , \qquad g_{s3} + f_{s3} = 1 , \qquad (D.7.12)$$

which yields:

$$f_{s1} = g_{a1} - 1, \qquad f_{s2} = g_{s2} - 1, \qquad f_{s3} = g_{s3} - 1. \qquad \text{(D.7.13)}$$

Using the results of **(D.7.13)** in **(D.7.11)** yields formula **(D.7.1)**:

$$N_{ot} = K_f \times \left[N_o + N_{s1} \times f_{s1} + N_{s2} \times f_{s2} + N_{s3} \times f_{s3} \right.$$

$$\text{(D.7.14)}$$

Notice that if no patrol work is done by field supervisors (i.e., if f **= 0)** and no special assignment personnel are used (i.e., if N_{s1} = N_{s2} = N_{s3} **= 0)** , then N_{ot} = N_o**)**.

APPENDIX **D.8:** <u>Determination of the Shift Relief Factor **(SRF)** for</u>
<u>the Calculation of the Total Number of Officers **(N,)**</u>
<u>and Field Supervisors **(N.)** Required Within the **APA**</u>
<u>(Section **8.2)**</u>

Introduction

The shift relief factor for a law enforcement agency is used to
determine the total number of officers that must be available
(i.e., both **on-** and off-duty) in order to support a specified
average number of on-duty officers each day. The shift relief
factor is defined as **"the** average number of persons required to
cover one shift position every **day."**

For agencies with **8-hour** shifts, shift relief factors typically
fall in the range of **1.60** to **1.90.** A shift relief factor of **1.70**
for an agency using **8-hour** shifts would indicate that the total
staff for regular duty should be approximately **1.7** times the
average number of on-duty positions that the agency plans to use
per day. As an example, in order to cover **10** positions a day, this
agency would have to have a total of **10 x 1.7 = 17** officers
available. (With **8-hour** shifts and one officer per unit, three
positions are needed every day to support one **24-hour** coverage
unit.)

Shift relief factors increase as the shift length increases.
Agencies using lo-hour shift will have shift relief factors in the
range: **2.00** to **2.40.** Relief factors for agencies with **12-hour**
shifts are in the range: **2.40** to **2.90.**

Derivation of the Shift Relief Factor for Patrol **Duty**

The shift relief factor is determined by the shift length, the
average work week, the average amount of benefit time off given to
each officer, and the amount of time officers spend on temporary
special assignments. Calculation of the relief factor for an
agency is usually based on data collected for one year and used in
the following formula:

$$SRF = \frac{365 \times S_l}{\text{Average Number of On-Duty Hours on Patrol Per Officer Per Year}} \qquad \text{(D.8.1)}$$

where:

SRF — shift relief factor (number of officers), and

S_l — shift length (hours).

The expression **365 x S_l** in **(D.8.1)** indicates the number of hours required to cover one position every day for an entire year. The denominator in **(D.8.1)** is the average number of on-duty hours provided by each officer in one year.

Determination of the Average Number of On-Duty Hours on Patrol Per Year Per Officer

One difficulty with the use of formula **(D.8.1)** is that few agencies actually keep track of hours worked. Rather, most personnel time-recording systems are designed to keep track of the amount of time off for each officer (e.g., for vacation, holiday, personal leave, etc.). Recognizing that fact, it is often easier to determine the shift relief factor for an agency if formula **(D.8.1)** is rewritten as:

$$SRF = \frac{365 \times S_l}{(365 \times S_l) - \text{Average Number of Non-Patrol Hours Per Year Per Officer}} \qquad \text{(D.8.2)}$$

In this form, the average number of on-duty hours per year per officer is calculated as:

$$(365 \times S_l) - \text{Average Number of Non-Patrol Hours Per Year Per Officer.} \qquad \text{(D.8.3)}$$

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The first term in **(D.8.3)** indicates the total number of hours that one officer would be on-duty if he/she worked every day of the year, The second term represents the average number of non-patrol hours per year per officer. Subtracting in **(D.8.3)** gives the average number of on-duty hours on patrol per year per officer. The usefulness of formula **(D.8.2)** is that it requires information (i.e., average non-patrol time per officer per year) that is maintained by most agencies.

The average number of non-patrol hours per year per officer can be grouped into three categories:

- Regularly-scheduled time off. Unpaid time off each officer receives based on the average work week used by the agency. As an example, a **40-hour** work week provide each officer with an average of two days off per week.

- Benefit time off. Paid time including vacation leave, holiday leave, personal time, and compensatory time. The different kinds of benefit time off given varies from agency to agency and from one part of the country to another.

- Temporary **special** assignments. On-duty time spent on non-patrol activities. For example, an officer sent to a one-week training course in another state is obviously not available for patrol duty, but is considered **"on** duty" while at the training. Whether non-patrol, on-duty time should be included in the determination of the relief factor is not rigidly defined. An analyst trying to justify as many officers as possible will likely not count non-patrol, on-duty time as on-duty patrol time in order to derive a higher relief factor. Another analyst, seeking to hold down staffing estimates, may decide to count all on-duty time whether spent on patrol or not to derive a lower value for the relief factor.

Formula **(D.8.3)** can be expressed as:

$$(365 \quad \times \quad S_1) \quad - \quad H_{rs} \quad - \quad H_b \quad - \quad H_{ta} \qquad (D.8.4)$$

where:

H_{rs} — number of regularly-scheduled hours off per officer per year,

H_b — number of benefit hours off per officer per year, and

H_{ta} — number of on-duty hours spent on temporary specialassignments (non-patrol) per officer per year.

Note that the expression **(365 x S_l) - H_{rs}** equals the annual number of paid hours. The annual number of paid hours **(H_y)** is also given **by:**

$$H_y \quad = \quad \frac{365 \quad x \quad AWW}{7} \qquad (D.8.5)$$

where **AWW** represents the average work week in hours. Note that if **AWW = 40,** HI,, is **2,085.7** hours per year. (The commonly used figure of **2,080** paid hours per year is based on exactly **52** weeks. Fifty-two weeks, however, only has **364** days, one day less than the actual year.)

Replacing **(365 x S_l) - H_{rs}** in **(D.8.4)** with **(D.8.5)** yields:

$$\frac{365 \quad x \quad AWW}{7} \quad - \quad H_b \quad - \quad H_{ta} \qquad (D.8.6)$$

Using **(D.8.6)** as the denominator in **(D.8.1)** yields:

$$SRF \quad = \quad \frac{365 \quad x \quad S_l}{\frac{365 \quad x \quad AWW}{7} \quad - \quad H_b \quad - \quad H_{ta}} \qquad (D.8.7)$$

APPENDIX **D.9:** <u>Allocation of Patrol Personnel **Among**
Several **APAs** (Worksheet **9)**</u>

<u>Introduction</u>

Worksheet 9 provides two methods for allocating a given number of
staff among several **APAs.** Both methods rely on staffing estimates
for each **APA** provided by the PAM model in worksheets **1 - 8.** The
first method, identified as @@unconstrained allocation,@@ indicates
the ideal staffing if no limitations are imposed on how many
officers **can** be added or subtracted from the current staffing level
in any **APA** (i.e., if there are no limitations on transfers between
APAs). The second method, identified as @@constrained allocation,@@
can be used to determine the staffing allocation when a fixed
number of additional officers are to be added and no transfers of
existing personnel are allowed. In this case, the no transfer
constraint has the effect of insuring that no **APA** will <u>lose</u>
staffing because of the allocation. The constrained **allocation**
procedure can also be **used** to determine which **APAs** will lose
personnel when staff reductions are required. In this case, the no
transfer rule insures that no **APA** will <u>**gain**</u> personnel as a result
of the overall staff reductions. All of the calculations for
Worksheet 9 **are summarized in** Table **4-1.**

The derivations below make use of the following notation:

T - total number of staff in all of the **APAs** after the
reallocation

TA - total number of new staff (or total staff to be
deleted)

TA_i - total number of staff added to **APA** i (or staff de-
leted from **APA i)**

TC - current total number of staff among all of the **APAs**

TC_i - current number of staff in **APA** i

TE - total number of staff estimated by the PAM model
for all of the **APAs**

$\textbf{TE}_i$ - total number of staff estimated by the PAM model for **APA i**

$\textbf{T}_i$ - total number of staff in **APA** i after the reallocation

The total staff to be allocated is given by:

$$T = \textbf{TC} + \textbf{TA} \qquad (D.9.1)$$

Unconstrained Allocation

The rationale for the unconstrained allocation is that the total staff **(T)** should be distributed among the **APAs** in the same proportion as the PAM estimates; i.e.,

$$\frac{T_i}{T} = \frac{\textbf{TE}_i}{\textbf{TE}}, \quad \text{all } \textbf{APAs} \qquad (D.9.2)$$

Solving for $\textbf{T}_i$ and replacing T with **(D.9.1)** yields the formula for the number of staff that should be assigned to each **APA:**

$$T_i = \textbf{TE}_i \times \frac{\textbf{TA} + \textbf{TC}}{\textbf{TE}} \qquad (D.9.3)$$

Constrained Allocation

The total staff to be allocated is given by **(D.9.1)** above. The difference **(d_i)** for each **APA** between the number of staff provided by the unconstrained allocation for the **APA (i.e, T_i** given in **(D.9.3))** and the number of staff estimated for the **APA** by the PAM model **(TE_i) is** given by:

$$d_i = T_i - \textbf{TE}_i \qquad (D.9.4)$$

Expression **(D.9.4)** indicates whether an **APA** is under or over-staffed; i.e.,

if $d_i > 0$, the **APA** is overstaffed,

if $d_i < 0$, the **APA** is understaffed.

The d_i values are used to identify which **APAs** should gain staff (if **TA > 0**) and which **APAs** should lose staff (if **TA < 0**).

Additional **staff** (**TA > 0**). If staff is to be added to the **APAs,** the no transfer rule can be satisfied by distributing the new staff only among those **APAs** that are understaffed (i.e., **APAs** with **di < 0**). Let **U** represent the collection of **APAs** that are under-staffed and determine the total deficit staffing (TN) for these **APAs** by summing the d_is in **U**; i.e.,

$$TN = d_1 + d_2 + d_3 + \ldots + d_n \qquad (D.9.5)$$

-- only use **APAs** for which $d_i < 0$ --

Allocation of the **TA** staff among the **APAs** in **U** is given by **(D.9.6)** below where **TA_i** represents the? number of staff added to **APA i:**

$$TA_i = d_i \times \frac{TA}{TN} \qquad (D.9.6)$$

The final allocation among all of the **APAs** is given by:

$$T_i = \left[\begin{array}{ll} TC_i & \text{if } d_i \geq 0 \\ TC_i + TA_i & \text{if } d_i < 0 \end{array} \right. \qquad (D.9.7)$$

Staff reduction **(TA < 0).** For staff reductions, the constrained allocation procedure uses the d_i values to identify those **APAs** that **are** overstaffed and, as a result, are eligible for staff reductions. Let 0 represent the collection of **APAs** that are overstaffed and determine the total surplus staffing (TN) for these **APAs** by summing the d_is in **O; i.e.,**

$$TN = d_1 + d_2 + d_3 + \ldots + d_n \qquad (D.9.8)$$

-- only use **APAs** for which $d_i > 0$ --

Allocation of the **TA** staff among the **APAs** in 0 is given by **(D.9.9)** below where TA_i represents the number of staff to be taken **from APA i:**

$$TA_i = d_i \times \frac{TA}{TN} \qquad (D.9.9)$$

Each TA_i **value** for staff reductions will be a negative **number.** The final **allocation** among all of the **APAs** is given by:

$$T_i = \begin{cases} TC_i & \text{if } d_i \leq 0 \\ TC_i + TA_i & \text{if } d_i > 0 \end{cases} \qquad (D.9.10)$$